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Organic floriculture for sustainable production: Advances in soil health, eco-friendly inputs and crop management

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Abstract

Organic floriculture is gaining importance as a sustainable production system that addresses the environmental concerns associated with conventional flower cultivation, particularly the excessive use of synthetic fertilisers and pesticides. These inputs contribute to soil degradation, ecological imbalance and reduced sustainability of ornamental crop production. This review presents recent advancements in sustainable organic practices in floriculture, emphasising the role of organic nutrient sources, biofertilisers, biostimulants, eco-friendly growing substrates and integrated pest and disease management strategies. Studies on organic production systems in major ornamental crops have reported improvements in plant growth, flowering attributes, flower quality, essential oil content and post-harvest performance. An integration of biological inputs, microbial inoculants, botanical-based pest management and environmentally safe cultivation practices offers promising alternatives for reducing chemical dependency. Sustainable resource management approaches, including water conservation techniques, protected cultivation, precision farming and improved post-harvest handling, further enhance the efficiency and resilience of organic floriculture systems. Additionally, organic certification standards, including International Federation of Organic Agriculture Movements (IFOAM), European Union (EU) organic and United States Department of Agriculture (USDA) organic, promote sustainable floriculture by restricting synthetic chemicals and encouraging environmentally responsible production practices. However, limitations related to nutrient availability, effective pest and disease management, production consistency and certification constraints continue to restrict widespread adoption. Future research should focus on developing efficient organic input formulations, innovative cultivation technologies and region-specific sustainable production models to enhance productivity, sustainability and adoption among farmers. This review highlights the potential of organic floriculture as a viable approach for achieving environmentally sustainable, economically viable and high-quality ornamental crop production.

Keywords: biofertilisers; eco-friendly inputs; integrated pest management; organic floriculture; soil health management; sustainable production

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1. Introduction

Floriculture, a major branch of horticulture, is increasingly under pressure to adopt environmentally sustainable production practices (1, 2). To meet market demand, conventional floriculture relies heavily on large quantities of synthetic fertilisers and pesticides, which may have negative environmental effects such as aquatic eutrophication, non-point source pollution and the accumulation of hazardous residues (3, 4). This requires a shift toward environmentally friendly production methods that balance agricultural productivity with ecological conservation (5, 6). The year-wise distribution of Scopus-indexed publications on organic floriculture (2002–26) is illustrated in Fig. 1. The trend reveals minimal research activity between 2002 and 2009, followed by a gradual increase through the 2010s. A sharp rise is evident from 2020 onward, peaking at 15 publications in 2024, indicating a growing scientific interest in organic floriculture in recent years, likely driven by the increasing global focus on sustainable agricultural practices.

The major strategies to adopt eco-friendly practices include integrated pest management (IPM), sustainable soil health management, biological control and new cultivation methods (7). Natural biological control, such as the application of plant growth promoting bacteria (PGPB), has been proposed as an ecologically safe solution to improve the yield of commercial flower crops such as roses, gerberas, carnations, chrysanthemums and orchids (3).

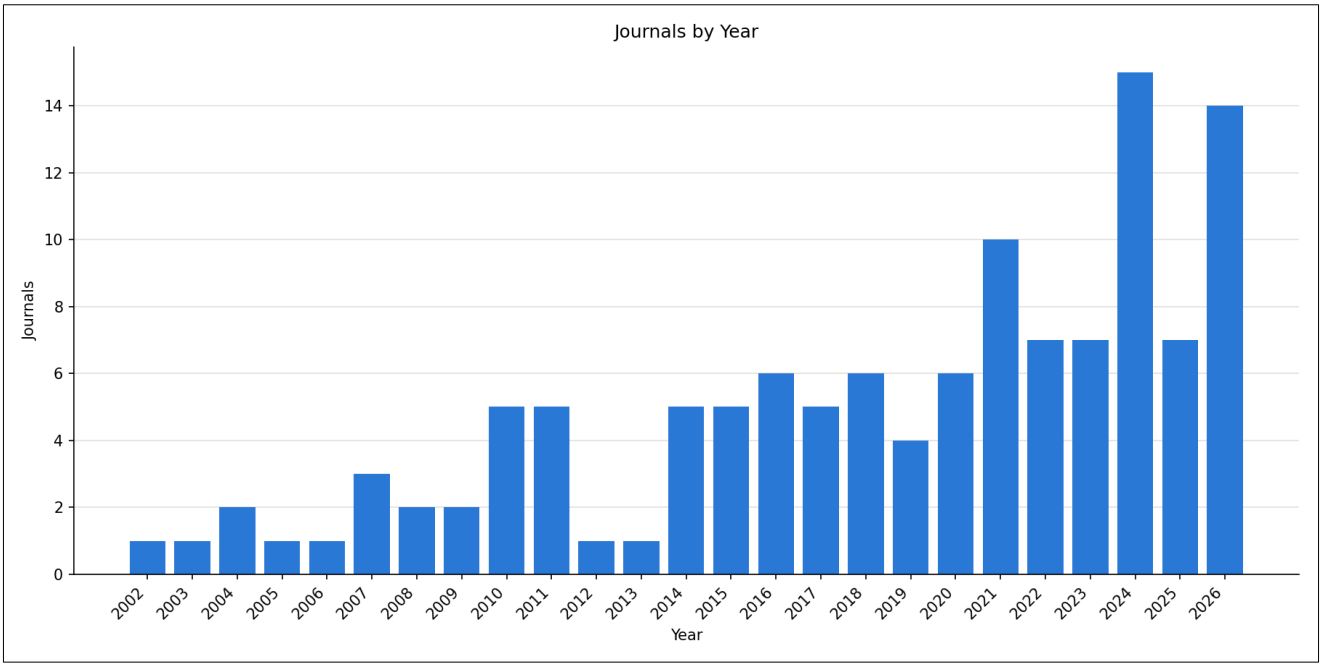


Fig. 1. The year-wise distribution of Scopus-indexed publications on organic floriculture (2002–26).

The cultivation of organic flower crops addresses critical environmental concerns such as carbon dioxide (CO_2) emissions and greenhouse gas production, which are reduced compared to conventional farming (8). This holistic approach enables floriculture to meet both economic and ecological objectives (9). Managing the transition to organic production is crucial to mitigating the negative environmental and health impacts of chemical-intensive agriculture, enhancing biodiversity and creating more resilient agricultural landscapes (10, 11). This review synthesises recent advances in organic floriculture, focusing on sustainable soil health, biological inputs and eco-friendly crop management. It also identifies current challenges, research gaps and future directions to support the sustainable development of the floriculture sector.

Importance of organic floriculture in sustainable production

Traditional systems that rely heavily on synthetic fertilisers and pesticides can degrade soil by increasing acidity and salinity and by reducing beneficial soil organisms. They also contribute to higher losses of reactive nitrogen (N) and greenhouse gas emissions (12, 13). Eco-friendly nutrient management practices include the application of organic manures, compost, crop residues and biofertilisers in combination with reduced mineral fertiliser inputs. These practices improve soil structure, increase organic matter content, enhance nutrient use efficiency and promote plant growth and flowering (13, 14). Studies show that organic and integrated systems improve flower quality, extend vase life and increase economic returns in crops such as carnations and chrysanthemums (15, 16).

The principles of organic farming framed by International Federation of Organic Agriculture Movements (IFOAM) are based on four interconnected ethical pillars as shown in Fig. 2.

- **Principle of health** promotes healthy soil, plants and ecosystems through organic nutrient management, compost use and biological inputs to enhance flower production and quality.
- **Principle of ecology** encourages sustainable flower production by integrating natural processes, biodiversity conservation and ecological crop management practices.
- **Principle of fairness** supports ethical organic floriculture by ensuring responsible resource use, safe practices and equitable benefits for growers, workers and consumers.
- **Principle of care** emphasises precautionary and sustainable management of resources to reduce environmental impacts and maintain long-term productivity.

Soil management in organic flower production

Soil health is considered a key component of sustainable practices because it serves as the foundation of agricultural systems, supporting plant growth, supplying water and nutrients and providing resistance to degradation due to pollution, acidification, salinisation and erosion. Excessive use of fertilisers, pesticides and plastic in conventional farming kills soil biota, which degrades biodiversity through disruption of microbial populations and decreases the production and quality of crops. Monoculture cropping and negative plant–soil feedback lead to the accumulation of soil-borne pathogens and increase soil-borne diseases; when combined with high-input flower farming, these factors contribute to the further breakdown of soil health (13).

Ecological functions of soil Floriculture systems rely on soil as a foundational substrate that provides mechanical support, water and nutrients required for the growth of flowers (13).

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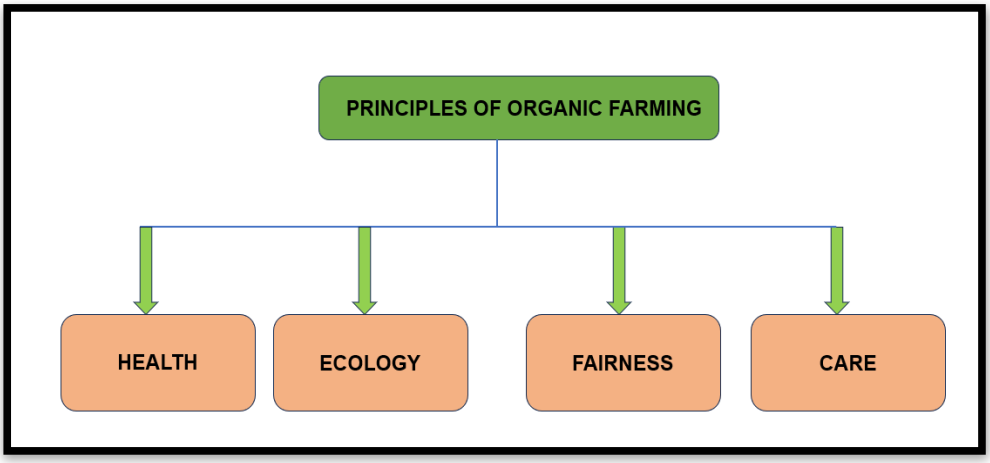


Fig. 2. Principles of organic farming classified by the International Federation of Organic Agriculture Movements (IFOAM) into four categories.

○ Nutrient cycling and decomposition are facilitated by a variety of soil organisms (bacteria, fungi and fauna), which help to maintain long-term fertility without relying on synthetic inputs (13, 17).

○ Edaphic factors (pH, organic carbon and nutrient availability) influence soil mesofauna such as Collembola in flower fields. Collembola are considered indicators of soil quality because their abundance and diversity reflect changes in soil conditions, organic matter status and microbial activity, contributing to soil fertility and ecosystem functioning (18).

○ Organic matter and humic substances improve nutrient availability, pollutant detoxification and carbon sequestration, which supports plant vitality and climate regulation. Commonly used organic amendments in floriculture include farmyard manure (FYM), compost, vermicompost, green manure, poultry manure, coir pith compost and biochar, which improve soil fertility, microbial activity and overall soil health (19, 20).

○ Soil organisms naturally suppress soil-borne pests and diseases, reducing dependence on synthetic pesticides and supporting sustainable flower production (17, 21).

Eco-friendly inputs for organic flower crops

Role of organic inputs

Organic materials of plant and animal origin are widely used as fertilisers and soil amendments, including manure, compost, biogas slurry, FYM and crop residues. The roles of eco-friendly inputs in the production of organic flower crops are illustrated in Fig. 3. Organic amendments such as chicken and barnyard manure improve soil fertility, nutrient availability and plant growth in *Tagetes erecta* L., while vermicompost enhances soil structure, microbial activity and flowering performance in China aster, gladiolus and chrysanthemum. Combinations of vermicompost, rock phosphate and microbial consortia in chrysanthemum cv. Snowball improve vegetative growth, flowering and flower weight compared with conventional fertilisers (22).

The main source of nutrients to support environmentally friendly production in floriculture is organic inputs (FYM, compost, vermicompost, green manures, biofertilisers, press mud, oilcakes, etc.). Additionally, they are utilised in the production of organic flowers as substrate media, components of potting mixes, plug/nursery media, soil drenches, bulb soaks, foliar sprays and for hardening tissue-cultured plants (23). New or enhanced organic materials (e.g., a humanure-biochar-urine mix and biochar-blended compost) can increase flower production and enhance soil fertility and quality in marigold (24). Recommended combinations of organic growing media for flower crops are presented in Table 1.

Need for eco-friendly organic formulations

The organic formulations comprise organic manures, composts, liquid inputs, biostimulants and organic-based substrates, which are substitutes for synthetic fertilisers and pesticides to maintain flower yield and quality (29). Organic media such as FYM, vermicompost, phospho-compost, press mud, biogas slurry, oil cakes, crop residues and green manures are incorporated into beds, nursery media, potting mixtures and greenhouses as a source of slow-release nutrients to enhance bed structure and water retention (23, 30, 31).

Liquid formulations such as Jeevamruth, Panchagavya, Amritpani, Beejamruth and seaweed extract are applied as soil drenches, bulb dips, or foliar sprays. These formulations are easy to prepare and economically effective, as they improve nutrient availability, enhance beneficial microbial activity and support plant growth and flowering in organic floriculture systems (29). The combination of compost teas, bio-slurry and other bioproduct-based residues serves as biofertilisers and biostimulants and is equal to conventional fertilisers in the biomass of ornamentals such as petunia and impatiens (32).

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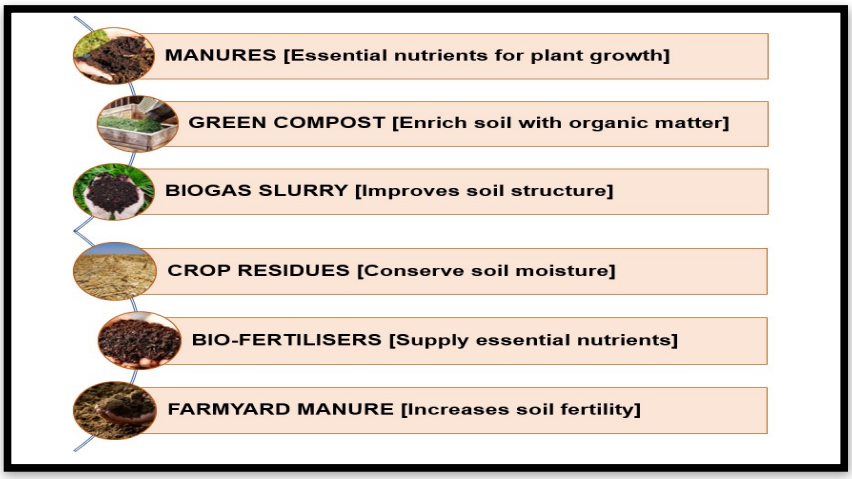


Fig. 3. The roles of eco-friendly inputs in the production of organic flower crops.

Table 1. Recommended combinations of organic growing media for flower crops

Sl. No	Crop	Combinations	Observed effects	References
1	Potmum (Chrysanthemum)	Cocopeat + vermicompost + leaf mould (2 : 1 : 1)	Plant height 41.95 cm, flower diameter 4.97 cm, flower yield 519.67 g plant^{-1}, 214.11 flowers plant^{-1}, vase life 24.44 days.	(25)
2	Alstroemeria 'Capri'	Sand + soil + FYM + vermicompost + cocopeat	Plant height 123.54 cm, cut stem length 103.83 cm, cut stem weight 61.80 g, Flowering stems 34.80 plant^{-1}, Vase life 12.50 days.	(26)
3	Stock	Biochar + peat + leaf compost	Plant height 56.7 cm, Shoot fresh weight 86.4 g, Root fresh weight 18.2 g	(27)
4	Osteospermum	Peat + 15–30 % sugarcane bagasse	Maintains quality of standard peat and an optimal pH, suitable peat substitute for commercial production.	(28)

FYM: farmyard manure.

Cultivation of organic flower crops

Rose

Organic cultivation of oil-bearing roses has been found to yield more linalool and geraniol as well as more antioxidant activity but with a lower total oil content than conventional production (33). The contrasting findings may be attributed to differences in nutrient availability, cultivar, soil conditions and environmental factors. Organic cultivation generally promotes the synthesis of secondary metabolites, enhancing essential oil quality, whereas conventional nutrient inputs often favour higher biomass and oil yield. Overall, the available evidence suggests that organic production improves essential oil quality, although a trade-off with total oil yield may occur under certain production conditions. Vermicompost and animal manures increase fresh petal weight, essential oil yield and monoterpene alcohols (β-citronellol, geraniol), thereby improving oil quality in damask rose compared to conventional methods (34). Composting and reusing rose waste alone or blended with other residues enhances soil organic matter by about 30 %, improves nutrient availability and increases stem yield, partially substituting fertigation without compromising stem length or bud size under commercial greenhouse conditions (35, 36). Studies of exogenous organic carbon (organic fertilisers, biochar) in red soils show that these inputs reshape rhizosphere bacterial communities and increase soil organic carbon, available phosphorus (P) and beneficial microbes, thereby enhancing cut rose yield and quality (37).

Sucking pests are controlled using botanical and natural products (e.g., orange oil, bee glue and neem) that have no negative impact on beneficial arbuscular mycorrhizal fungi (38, 39). In general, organic rose production has the potential to provide high-quality flowers and oils with environmental co-benefits. There are difficulties in terms of disease and pest resistance, lower oil yields in several instances and higher production and management requirements for growers (33, 40).

Chrysanthemum

Organic liquid fertilisers such as shrimp, seaweed, fish and farm-prepared organic inputs such as Jeevamrut and Panchagavya are capable of increasing shoot and root growth by 10–78 %, which stimulates chlorophyll and promotes rhizosphere microbial activity compared to mineral NPK (41, 42). Biofertilisers and vermicompost, along with beneficial microorganisms

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(e.g., *Paenibacillus polymyxa*, *Azotobacter*, phosphate-solubilising bacteria and *Trichoderma*), enhance flower yield and quality and also prevent soil-borne diseases such as *Fusarium* wilt. They also rehabilitate continuous cropping soils and perform better than synthetic fertilisers (43–45).

Marigold

The use of organic manures like vermicompost at 20 t ha^{-1} and poultry manure positively influenced morphological traits and floral attributes in African marigold (*T. erecta*), which led to increased flower production (46). Enriched humanure compost contains stabilised organic matter and essential nutrients that improve soil structure and microbial activity. When properly composted to eliminate potential pathogens, it can enhance marigold growth and increase flower production in organic floriculture systems (24). Application of effective microorganism (EM) compost enhances carotenoid content by improving soil health and nutrient availability (47).

Tuberose

A combination of FYM, vermicompost, PSB, *Azospirillum* and 50–75 % of the recommended dose of chemical fertilisers enhances plant height, spike length, number of florets and flower yield compared to chemical fertilisers (48). Vermicompost enriched with beneficial microbes can replace up to 50 % of synthetic fertilisers, enhancing soil microbial activity, enzymatic functions, nutrient availability and flower quality (49). A combination of FYM and vermicompost at higher doses (e.g., 75 t ha^{-1} FYM + 30 t ha^{-1} vermicompost) yields the highest bulb yield per area (50). Additionally, biocontrol agents like *Trichoderma* enhance tuberose growth, flowering and bulb quality (51).

Jasmine

Vermicompost and Panchagavya (fermented cow-based biostimulant) enhance plant height, shoot and leaf counts and flower yield (to approximately 3.8 t ha^{-1}), while extending the shelf life of loose flowers (52). Nutrient levels in jasmine flowers and leaves were highest in the integrated nutrient management (INM) where vermicompost supplied all N requirements, while biofertilisers such as *Azotobacter* and PSB enhanced N and P availability (53). The combination of biopesticides along with *Trichoderma*, *Bacillus*, biofertilisers (*Azospirillum*, phospho-bacteria) increases growth and yield and simultaneously controls budworms, mites and whiteflies (54).

Orchid

Organic materials are used commercially as potting media (cocopeat, bark, sphagnum moss) for plug and nursery production, soil drenches, bulb and seedling soak solutions and foliar spray solutions to protect plant regimes (55). Fern stem-based substrates used as potting media for potted *Dendrobium* increased tiller production by 32.93 % (2.22 tillers per plant) compared with wood charcoal (1.67 tillers per plant) (56). Organic additives like coconut water, apple juice and banana homogenate used in tissue culture and seedling stages have consistently been found to induce protocorm development, shoot multiplication and seedling biomass in orchids (57). The symbiotic relationship with mycorrhizal fungi played a significant role in the nutrition supply of orchids and mature orchids obtain a significant share of their organic carbon through fungal associates (58).

Water conservation and management

Development of irrigation methods is also part of sustainable water management, which includes partial root-zone drying and precision irrigation with the help of Internet of Things (IoT) and artificial intelligence (AI) technologies that can be useful in increasing water use efficiency. Internet of Things-based sensors enable real-time monitoring of soil moisture and environmental conditions, while AI technologies support data-based irrigation scheduling and optimise water application, thereby improving water use efficiency (59). For example, mulching and soil treatments could reduce non-beneficial water use by 20 % in the on-farm water-saving practices. Similarly, the adoption of organic farming systems has been shown to enhance freshwater sustainability by reducing overall water-use coefficients, particularly in regions where environmental awareness and supportive policy incentives promote their uptake (60).

Efficient irrigation scheduling is essential for sustainable organic floriculture, as it optimises water use while maintaining plant growth and flower quality. Techniques such as drip irrigation, deficit irrigation and sensor-based systems deliver water directly to the root zone, reducing evaporation and runoff losses. Irrigation water should have suitable pH, electrical conductivity (EC) and low levels of salts and contaminants to ensure optimum nutrient availability and healthy plant growth. Poor-quality water can impair nutrient uptake, reduce microbial activity and adversely affect flowering performance. Rainwater collected from greenhouse roofs, shade-net structures and farm buildings can be stored in tanks or farm ponds for irrigation during dry periods. Its low salt content makes it a suitable and sustainable water source for ornamental crops.

Water management under protected cultivation

Greenhouses and polyhouses enable efficient water management through controlled environmental conditions. Drip irrigation, automated irrigation controllers and soil moisture sensors ensure precise water application, minimising wastage while maintaining optimal root-zone moisture.

Water conservation in organic versus conventional floriculture

Organic floriculture conserves water more efficiently than conventional systems by improving soil moisture retention through compost, vermicompost and other organic amendments. In contrast, conventional systems often rely on synthetic inputs that contribute less to soil structure. Combining organic amendments with mulching, rainwater harvesting and precision irrigation further enhances water-use efficiency and sustainability.

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Climate-resilient practices

Climate-resilient practices use a combination of novel technologies as well as traditional agroecological approaches to help flower production systems adapt to climate change, which includes extreme heat, drought and irregular rainfall. Some of these strategies include the use of heat and drought-resistant cultivars, advanced water management systems such as drip irrigation and rainwater harvesting, soil reuse coupled with organic amendments and conservation tillage to improve the health and productivity of soil (61–63). Climate-sensitive practices including mulching, intercropping, crop rotation and agroforestry help address climate-related challenges and mitigate climate shocks (64). Greenhouses and hydroponic systems provide protection against extreme weather, offer controlled growing environments and reduce exposure to climate fluctuations (61).

Crop protection strategies in flower crops

Integrated pest management

Integrated pest management is an ecological and sustainable approach that combines prevention, monitoring and control strategies to keep pest populations below economic thresholds while minimising the use of synthetic pesticides. Organic flower crop practices include the use of clean planting material, resistant or tolerant varieties, sanitation, optimal nutrition, irrigation and habitat manipulation (e.g., flower strips or banker plants) with the intention of conserving and increasing the natural enemies (62, 63). The control methods used for pest management include biological methods (predators, parasites), cultural practices (crop rotation), physical methods (traps, mulching) and chemical approaches (62). Experiments on chrysanthemums have shown that cultural (mulching, root dips), mechanical (blue sticky traps), biorational (*Pongamia* soap) and selective insecticides can lower thrips and other target pests (64). Major pests affecting organic flower crops include aphids, thrips, whiteflies, spider mites and caterpillars. These pests can be effectively managed using organically approved methods such as neem oil, insecticidal soaps, coloured sticky traps, pheromone traps and *Bacillus thuringiensis* (Bt). Biological control agents, including *Beauveria bassiana*, *Metarhizium anisopliae*, *Trichoderma harzianum*, *Bacillus subtilis*, predatory mites (*Phytoseiulus persimilis*), ladybird beetles (*Coccinella septempunctata*) and parasitoids (*Encarsia formosa*), have shown good efficacy in suppressing insect pests and soil-borne pathogens while reducing reliance on synthetic pesticides.

Integrated disease management

Integrated disease management focuses on the prevention of the following major diseases such as Botrytis blight, powdery mildew and soil-borne wilts. Preventive strategies, including the use of clean planting material, good sanitation and microclimatic control (humidity, ventilation and spacing) in greenhouses and polyhouses are recommended. In flower crops such as petunia, rose and gladiolus, biorational products (beneficial bacteria including *Pseudomonas*, natural fermentation product natamycin, calcium formulations, resistance inducers and botanical/essential oils) may be used to reduce the severity of botrytis disease (65, 66).

Post-harvest management in organic floriculture

Post-harvest management is essential for maintaining the quality, freshness and vase life of cut flowers. Proper harvesting at the appropriate stage, careful handling, grading, packaging and storage help minimise mechanical damage and preserve flower quality. To extend vase life, organic floriculture uses natural preservatives such as *Aloe vera* gel, chitosan, essential oils and sucrose–citric acid solutions to reduce microbial growth and improve water uptake. In contrast, conventional systems commonly rely on synthetic preservatives such as silver thiosulphate (STS) and 8-hydroxyquinoline citrate (8-HQC), which are effective but may have environmental concerns. Thus, organic preservatives provide a sustainable and eco-friendly alternative for maintaining post-harvest quality.

Natural preservatives and shelf-life enhancement

Eco-friendly preservation aims to extend the lifespan of flowers and avoid the use of harmful chemical preservatives or heavy metals. The most popular preservation techniques are plant-based extracts, essential oils, natural hormonal regulators (melatonin and putrescine), gel-based products and other forms of microbes. Cut flowers can be preserved using environmentally friendly methods which prevent the growth of bacteria in the vase water, improve water balance and enhance the natural defence mechanisms of cut flowers against bacterial blockage (67).

A number of experiments have reported that essential oils and plant extracts (green tea and cinnamon) applied to cut flowers (chrysanthemum, gladiolus, gerbera) double the vase life, increase water flow into the flower by the xylem and decrease the number of bacteria growing on the xylem of the flower (67–69). Melatonin (100 and 200 µM) and putrescine (1.5 mM) can increase the shelf life of *Alstroemeria* and improve the market level (70).

Organic certification standards and regulations

Organic certification standards, such as IFOAM-based standards, European Union (EU) organic regulations and United States Department of Agriculture (USDA) Organic standards, primarily focus on limiting the use of synthetic chemicals, pesticides and fertilisers. While these standards promote organic production, they often emphasise the restriction of chemical inputs more than broader environmental sustainability outcomes (71). The advantages of market differentiation of certified organic crops include providing consumers with assurance of compliance with environmentally responsible production and creating opportunities for enhanced market potential (72). This is one of the reasons many flower exporters adopt additional certifications including Fairtrade or GLOBALG.A.P., which have stricter pesticide lists, worker safety, labour rights and broader resource protection measures (73, 74). The cost and complexity of third-party certification can discourage smallholders; therefore, alternative models such as

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internal control systems (ICS) and participatory guarantee systems (PGS) have been adopted. The ICS allows farmer groups to manage internal monitoring and certification processes, while PGS uses peer review and stakeholder participation to verify organic practices and improve market access for small-scale organic flower growers (75).

Environmental impacts

1. Organic floriculture avoids synthetic fertilisers and pesticides, which minimises the risks of water pollution, ecotoxicity, soil acidity and salinisation in comparison with conventional floriculture (13).

2. Ecosystem services provided by soil and biodiversity, such as nutrient cycling, carbon storage and habitat support, enhance soil resilience by maintaining nutrient availability, improving soil structure and regulating environmental conditions. These processes help reduce soil degradation and support productivity, particularly in dry and fragile environments (76). The environmental benefits of organic inputs in flower production are shown in Fig. 4. It summarises the environmental benefits of organic floriculture by showing how sustainable practices minimise environmental risks while conserving biodiversity, protecting habitats and enhancing ecosystem services.

3. In the floriculture sector, planting a wide range of ornamental species and indigenous species supports habitat protection by providing resources for beneficial organisms and enhances carbon sequestration through increased plant biomass and soil organic matter (2, 77).

Challenges

A major challenge in organic floriculture is nutrient management; organic fertilisers often release nutrients slowly and asynchronously with crop demand, which can lead to reduced yields (78). Weeds and pests are not only labour-intensive but also costly to manage and control and hence represent a significant management issue in the absence of synthetic chemicals (78, 79). Unsustainable cultivation practices can negatively affect soil health, water quality and community well-being, creating social and environmental challenges for the floriculture sector. These impacts highlight the need for integrated solutions and effective policy support to promote sustainable organic floriculture (80).

Research gaps

In organic floriculture, there is limited knowledge about soil health and sustainable soil management practices because existing research focuses on general agriculture but seldom on flower crops. Issues such as soil acidification, salinity, pesticide residues and plastic pollution in floriculture soils require targeted research to develop effective management strategies. Such studies can support the development of stress-tolerant cultivars and improve flower waste recycling practices to enhance the sustainability of floriculture systems (13). Moreover, there are knowledge gaps in the floriculture industry of Africa regarding adaptation to climate change, pests and pathogen control and cultivation of resistant and adaptive varieties, which creates the necessity of region-specific research (81).

Future perspectives

Organic flower production will integrate modern technologies, efficient resource management systems and sustainable organic practices to enhance productivity and environmental sustainability. Future progress will focus on combining precision devices and artificial intelligence with controlled-environment agriculture (e.g., hydroponics, greenhouses and vertical farms) to optimise water and nutrient use efficiency while eliminating synthetic inputs (82, 83). Emerging technologies such as AI, IoT, drones and remote sensing have the potential to enhance organic floriculture through early pest detection, precision irrigation and real-time crop monitoring. These technologies can improve resource-use efficiency, reduce input costs and support sustainable production while maintaining organic standards.

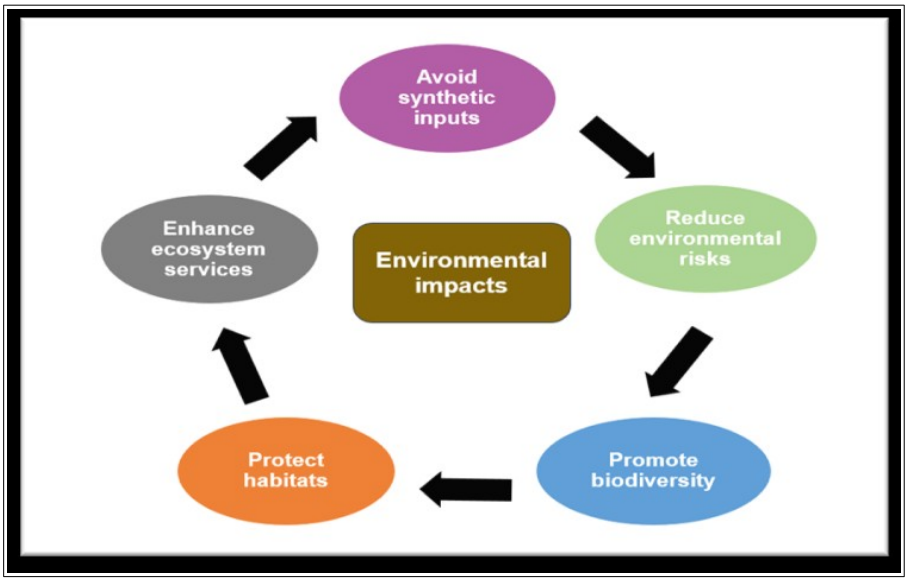


Fig. 4. The environmental benefits of organic inputs in flower production.

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Future technologies will develop systems that combine organic nutrients/fertilisers with different plant growing media capable of working either in the field or in plant factories. Synergies between organic production and closed growing systems, such as plant factories, can improve resource efficiency through controlled nutrient management, water recycling and reduced environmental impacts. These systems may support sustainable plant production by minimising resource losses and enhancing input-use efficiency (83, 84). However, their adoption is constrained by high initial costs, limited technical expertise and inadequate infrastructure, particularly for small-scale growers. Greater investment in research, farmer training, financial incentives and supportive government policies are needed to promote the adoption of smart technologies and strengthen the future of organic floriculture. Simultaneously, consumer demands for sustainability in corporations, transparent supply chains and reduced environmental impact will probably require floriculture companies to implement certifications, eco labels and greener logistics to bring market incentives closer to more sustainable organic practices (85).

2. Conclusion

Organic floriculture represents a sustainable approach to flower production by reducing dependence on synthetic inputs and enhancing soil health, biodiversity and environmental quality. The integration of organic nutrient management, eco-friendly pest control and efficient water use can improve productivity while maintaining ecological balance. This review highlights that the successful adoption of organic floriculture depends on integrating soil health management, organic inputs, biological crop protection, climate-resilient cultivation practices and sustainable post-harvest management within a holistic production system. However, challenges such as nutrient management, pest control and certification barriers must be addressed through research, technological innovation and policy support. Overall, organic floriculture offers significant potential to support environmentally responsible, economically viable and resilient flower production systems for the future.

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Authors' contributions

BS conducted the literature survey, analysed the data and drafted the manuscript. CR guided the preparation of the manuscript, provided critical revisions and approved the final version of the manuscript. KS contributed to the conceptualisation of the review and critically reviewed the manuscript. JP provided additional inputs and contributed to the review of the manuscript. BRPV assisted in data collection, data analysis and critical review of the manuscript. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest

Authors do not have any conflict of interests to declare.

Ethical issues

None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the authors used Grammarly and QuillBot solely for language editing and improving readability. The authors reviewed and approved the final manuscript and take full responsibility for its content.

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