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Advances and insights into natural farming for sustainable horticultural production

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Abstract
Feeding a rapidly growing global population has been a major challenge since independence. Although high-yielding farming practices have ensured food abundance, they have also contributed to environmental degradation, soil health decline, and biodiversity loss. Natural farming, a chemical-free approach rooted in traditional Indian agriculture and strengthened by contemporary ecological principles, offers a sustainable alternative. It is an agroecology-based system that integrates crops, trees, and livestock to promote functional biodiversity, enhance soil fertility, and reduce reliance on synthetic inputs. Core practices include biomass mulching, application of cow dung-urine formulations, soil aeration, and on-farm biomass recycling, thereby lowering input costs and enhancing rural livelihoods. In the horticulture sector, natural farming addresses challenges such as high production costs, pest pressures, and soil degradation, while aligning productivity with environmental sustainability. Mixed farming systems—such as crop-livestock, crop-forestry, crop-horticulture, fish-pig, fish-duck, and paddy-fish—further strengthen the benefits by improving resource-use efficiency, diversifying income, and reducing production risks. These integrated approaches enhance nutrient cycling, resilience to climatic variability, and profitability. This review synthesizes current knowledge on natural farming practices in horticultural crop production, highlighting their potential to improve farm productivity, reduce environmental impacts, and contribute to sustainable agricultural development.

Keywords: Environmental pollution; sustainable farming systems; organic agriculture; water resource scarcity

Introduction

Natural farming in Indian horticulture: an overview

For decades, Indian horticulture has focused on increasing productivity, often relying heavily on fertilizers and pesticides. The technological advancements of the 20th century revolutionized horticulture, yet their long-term impacts have raised concerns. Excessive chemical use has contributed to declining nutritional and medicinal quality of crops, soil degradation, water scarcity, polluted water bodies, and increased climate variability. Amidst these challenges, farmers face the pressure of feeding a growing population with "twentieth-century appetites," while climate warming threatens to reduce farm incomes in India by 20-25% in the coming decades. The situation is exacerbated by water shortages, post-harvest losses, depletion of natural resources, and the global warming crisis (Ram & Pathak, 2016; Sathish *et al*., 2022; Ahmed & Babita, 2015; Beni *et al*., 2021) [11, 13, 1, 2]. Natural farming offers an ecologically sustainable alternative, optimizing nature's ecosystem services to address food production challenges. Sometimes referred to as traditional farming, it is a chemical-free, diversified agricultural system integrating crops, livestock, trees, and functional biodiversity. It reduces dependence on market-purchased inputs, thereby lowering production costs (Reddy, 2012; Kayesh *et al*., 2023) [12, 5]. While distinct from biodynamic farming, natural farming shares similarities with sustainable agriculture, agroecology, agroforestry, permaculture, and organic farming—though it does not require certification. As a farming approach, natural farming enhances soil fertility, conserves biodiversity, reduces greenhouse gas emissions, and supports farmer livelihoods. It aligns with global sustainable agriculture goals, enabling food production

without compromising the needs of future generations (Dorais & Alsanius, 2015; Kumar *et al*., 2020; Lastochkina *et al*., 2022; Ouma & Jeruto, 2010) [4, 7, 8, 10]. The FAO projects that global food production must increase by 70% by 2050 to meet the needs of the growing middle class and expanding population. India, expected to become the world's most populous country by 2030 with 1.51 billion people, must adopt sustainable methods to secure its food future. In India, adoption patterns vary: most farmers in Andhra Pradesh have embraced natural farming within the last five years, while in Karnataka, the practice has deeper roots, with some farmers following it for over 15 years—largely due to the grassroots movement initiated by the Karnataka Rajya Raitha Sangha (KRRS) in 2002 (Khadse & Rosset, 2019) [6]. Natural farming thus emerges as both a revival of traditional wisdom and an innovative response to the pressing challenges of climate change, resource depletion, and environmental degradation in horticultural production.

Scope of natural farming in India

Modern societies inhabit a cultivated planet, with approximately 38% of global land dedicated to agriculture. Soil health forms the foundation for sustaining agricultural and livestock production, which together account for over 95% of global food supply. However, current agricultural systems are a major source of biogenic greenhouse gas emissions and are significant contributors to soil and environmental degradation. Key drivers include deforestation, overgrazing, intensive ploughing, and unsustainable farming practices. In India, fertilizer consumption has increased sharply, and pesticide use has become widespread in efforts to protect crops from weeds, fungi, and insect pests. These biotic stresses—along with diseases—cause an estimated 15-25% loss in potential agricultural yield. While pesticides provide short-term protection, their overuse depletes biodiversity, disrupts ecological balance, and leads to long-term environmental harm. Natural farming offers a promising pathway to reverse these trends by promoting chemical-free, ecologically balanced, and biodiversity-friendly practices. By enhancing soil fertility, conserving water, and reducing dependence on synthetic inputs, natural farming supports both the current and future sustainability of India's agricultural landscapes. It holds the potential to secure food production while safeguarding the ecosystem for generations to come.

Natural farming from a global perspective

Globally, there is growing consensus on the urgent need to replace conventional, resource-intensive agricultural practices with more sustainable alternatives. Rising awareness of the harmful impacts of indiscriminate pesticide use has also driven consumer demand for "organic" and chemical-free produce. This shift underscores the necessity of adopting diverse strategies—such as natural farming, organic farming, and agroecological approaches—to ensure long-term agricultural sustainability. India has historically been recognized as a repository of knowledge in biology, philosophy, and spirituality, offering time-tested wisdom in harmonizing human activity with nature. The foremost challenge today lies in restoring degraded natural resources and mitigating the adverse effects of modern agricultural technologies. This requires a holistic approach that addresses every component of the agricultural system—integrating soil health, biodiversity, water management, and community well-being—while ensuring productivity and resilience for the future.

What is natural farming?

Natural farming is a climate-resilient, low-input, indigenous agricultural practice that eliminates the use of synthetic chemical agro-inputs in India. Instead, it relies on locally available, cost-effective resources—such as cow dung and urine, jaggery, pulse flour, crop residues, mulch, and green cover—to enhance soil microbiological activity and improve overall farm ecology. This approach prioritizes the enrichment of organic matter, diversification of crops, effective biomass recycling, and the creation of stronger biological interactions within the farming system.

Natural farming adopts a holistic, agroecological framework that integrates practices such as crop rotation, mulching, composting, green manuring, intercropping, tree intercropping, and the integration of livestock. The core principles include:

1. Polycropping - integrating trees with diverse arable and perennial crops.
2. Zero synthetic inputs - avoiding chemical fertilizers, pesticides, and herbicides.
3. Year-round soil cover- maintaining mulch or cover crops to protect and nourish the soil.
4. Use of local seeds - selecting resilient, cost-effective varieties over hybrids.
5. Application of biostimulants- using natural catalysts to enhance soil microbial activity.
6. Minimal tillage - reducing soil disturbance to maintain structure and fertility.
7. Livestock integration - fostering biological and economic synergies between crops and animals.

Several Indian states actively promote natural farming, with Gujarat, Andhra Pradesh, and Himachal Pradesh at the forefront, followed by Madhya Pradesh, Tamil Nadu, Chhattisgarh, Odisha, Uttar Pradesh, and Jharkhand. The Government of India launched the Bharatiya Prakritik Krishi Paddhati (BPKP) under the Paramparagat Krishi Vikas Yojana (PKVY) in 2020-21 to promote this approach. Under BPKP, ₹49.8 crore has been allocated to cover over 6.1 lakh hectares across participating states. India's diverse agro-climatic zones and the wealth of traditional farming knowledge among its cultivators present vast opportunities for scaling natural farming as a sustainable, resource-conserving solution for the future (Kumar *et al.,* 2019) [7].

Principles of natural farming

Natural farming integrates traditional knowledge with ecological science to promote sustainable crop production. The approach emphasizes using trees, their parts, and their products for soil enrichment, pest management, and crop nutrition. Over the past two years, documented practices have highlighted the role of tree species with high nutrient content, rapid decomposition rates, and bioactive compounds in supporting crop health and productivity. Ancient literature also provides evidence of such applications, which now warrant deeper scientific validation.

1. Biomass Transfer Technique (BMT)

BMT involves the collection and incorporation of green biomass—particularly from nitrogen-fixing leguminous trees—into the soil prior to planting. This practice enriches soil nitrogen content, improves organic matter, and supports soil biota. Green leaf manure is prepared using locally available species known for high nitrogen content and fast decomposition. Commonly used species include:

Acacia auriculoformis, Acacia mangium, Albizia lebbek, Azadirachta indica, Cassia siamea, Delonix regia, Erythrina indica, Gliricidia sepium, Leucaena leucocephala, Peltophorum ferrugineum, Pongamia pinnata, Sesbania grandiflora.

2. Tree Leaf Extracts for Growth Promotion

Natural tree leaf extracts act as crop growth tonics. These are applied as seed treatments to enhance germination or as foliar sprays during various growth stages. The secondary metabolites present in these extracts stimulate physiological and biochemical processes in plants. Suitable horticultural tree species include:
Mangifera indica, Moringa oleifera, Aegle marmelos, Psidium guajava, Phyllanthus emblica, Phyllanthus acidus, Erythrina indica, Morinda tinctoria, Tabernaemontana coronaria, Alstonia scholaris, Dalbergia latifolia, Dalbergia sissoo, Sesbania grandiflora.

3. Tree Leaf Extracts for Crop Protection

Botanical extracts from leaves, seeds, kernels, and bark offer eco-friendly alternatives to synthetic pesticides. They contain secondary metabolites with antifungal, antibacterial, insecticidal, and antifeedant properties. Such extracts suppress pests, inhibit fungal spore germination, and disrupt insect growth and reproduction.

1. Tree species with strong biopesticidal properties

Adina cordifolia, Anthocephalus cadamba, Azadirachta indica, Eucalyptus camaldulensis, Gliricidia sepium, Morinda tinctoria, Pongamia pinnata, Vitex negundo.

2. Plant species with diverse biological activities in pest management

Includes *Aconitum ferox, Acorus calamus, Adhatoda vasica, Aegle marmelos, Allium cepa, Allium sativum, Annona squamosa, Artemisia vulgaris, Azadirachta indica, Calotropis procera, Cassia tora, Cinnamomum camphora, Curcuma longa, Datura metel, Melia azedarach, Mentha spicata, Moringa oleifera, Nicotiana tabacum, Ocimum sanctum, Piper nigrum, Ricinus communis, Tagetes minuta, Tephrosia purpurea, Vitex negundo, Zingiber officinale*, among others.

4. Key Natural Farming Practices in Horticultural Crops

a) Whapasa (Soil Aeration & Moisture Management)

Whapasa refers to maintaining the right balance of air and water in soil through organic matter buildup. In this method, irrigation is minimized—often applied only at midday in alternate furrows—to reduce water use while maintaining soil aeration and moisture.

b) Acchadana (Mulching)

Three mulching techniques are promoted:
Soil Mulch - avoids tillage, preserves soil structure, and improves moisture retention.
Straw Mulch - uses dried crop residues to enhance soil organic matter through microbial activity.
Live Mulch - intercropping monocots (e.g., cereals) and dicots (e.g., legumes) to supply complementary nutrients.

c) Beejamritha (Seed Treatment)

A microbial seed coating prepared from local cow dung, cow urine, lime, and soil. Protects seeds from soil- and seed-borne pathogens while enhancing germination and seedling vigor.

d) Jeevamritha (Liquid Microbial Inoculant)

A fermented mixture containing cow dung, cow urine, jaggery, pulse flour, and soil. Applied as a foliar spray or through irrigation twice a month to stimulate microbial activity and improve nutrient cycling.

e) Ghanajeevamritha (Solid Formulation)

A dry, solid form of Jeevamritha for water-scarce areas. Prepared into balls, sun-dried, and stored for up to six months before broadcasting in fields.

Applications in specific fruit crops

Mango: Incorporation of legumes in young orchards as green manure, application of 30-40 kg of organic manures per tree (via NADEP, vermicompost, or biodynamic compost), mulching, and targeted foliar sprays of Jeevamritha, Panchagavya, and biodynamic preparations (BD-500) post-harvest to enhance fruit quality and soil health.
Citrus: Compost as a primary nutrient source, applied before flowering; organic fruits have shown higher vitamin C content compared to conventionally grown fruits.
Guava: Organic cultivation with integrated use of manures and biofertilizers enhances yield, fruit quality, and vegetative growth.

Beneficial effects of panchagavya on fruit crops

Mango: Incorporation of legumes in young orchards as green manure, application of 30-40 kg of organic manures per tree (via NADEP, vermicompost, or biodynamic compost), mulching, and targeted foliar sprays of Jeevamritha, Panchagavya, and biodynamic preparations (BD-500) post-harvest to enhance fruit quality and soil health.
Enhances the number of female flowers and promotes dense blossoming.
Improves post-harvest quality, with fruits retaining marketable condition for up to 12 days at room temperature.
Acid Lime: Regular application of Panchagavya ensures year-round blooming and extends post-harvest shelf life by approximately 10 days, improving marketability.
Ensures continuous blooming throughout the year.
Extends shelf life by approximately 10 days.

Guava

- Increases total soluble solids (TSS).
- Prolongs shelf life by around 5 days.

Indigenous Technical Knowledge (ITK) Practices in Fruit Crops
Mango: Incorporation of legumes in young orchards as green manure, application of 30-40 kg of organic manures per tree (via NADEP, vermicompost, or biodynamic compost), mulching, and targeted foliar sprays of Jeevamritha, Panchagavya, and biodynamic preparations (BD-500) post-harvest to enhance fruit quality and soil health.
Control hopper infestation by spraying neem oil.
To promote flowering and repel hoppers, burn and fumigate dried leaves and twigs beneath trees either early in the morning (before sunrise) or late in the evening (after sunset).
Plant sunflower between mango trees to attract honeybees, enhancing pollination and fruit set.

Apple

- Intercrop with potato and pea for additional farm income.
- Use sod culture to reduce soil erosion.

Banana

- Apply 500 g of groundnut cake per sucker to boost productivity.
- Dust banana bunches with lime solution to accelerate ripening.
- Place neem leaves between banana bunches to facilitate ripening.
- Plant Sesbania spp. as a border crop to protect against wind damage.
- Apply 150 g of neem cake powder per sucker in the 3rd and 5th months to control nematodes.

Grapes

Cover bower sides with coconut or palm fronds to prevent wind damage, allow bird entry, and protect fruits from heat injury.

Guava

To control whiteflies, pound 2 kg of Calotropis leaves with 3 kg neem cake, soak in 20 liters of water for 4 days, then dilute in 200 liters of water, mix with 50 g detergent soap, and spray over 1 acre.

Mandarin Orange (*Citrus reticulata*)

- Treat stem borer infestation by lime washing the tree, cleaning the holes, and sealing them with cotton soaked in lime or wrapped in lemongrass.
- Mix ash with collected orange seeds to prevent ant damage.

Natural farming in vegetable production

Mixed Farming

Mixed farming is a traditional and sustainable agricultural practice combining the cultivation of two or more crop species with complementary systems such as livestock rearing or aquaculture. It is widely adopted in countries including India, Malaysia, Indonesia, Afghanistan, South Africa, China, Central Europe, Canada, and Russia. Initially subsistence-oriented, mixed farming is now increasingly practiced commercially in developed nations like the USA and Japan due to its efficiency, resource optimization, and income diversification potential.

Examples include combining cereal crops (wheat, rye) with livestock (cattle, sheep, pigs, poultry), where animal manure is used to fertilize fields.

Need for Mixed Farming in Vegetables

Relying solely on crop production makes farmers vulnerable to market fluctuations and crop failures. Mixed farming enhances sustainability, reduces economic risk, and ensures food security. By integrating crops with livestock or aquaculture, farmers can maximize land and labor use, diversify income sources, and stabilize returns. Examples include crop-livestock, crop-forestry, crop-horticulture, fish-pig, fish-duck, and paddy-fish systems.

Advantages of Mixed Cropping under Natural Farming

Boosts Soil Fertility: Different crops replenish or utilize soil nutrients in complementary ways, improving long-term fertility.

Increases Crop Yield: Crop rotation and diversity can increase yields by 10-25% over monocropping.

Enhances Soil Nutrients: Allows natural nutrient regeneration without chemical fertilizers.

Reduces Soil Erosion: Vegetation cover protects soil from erosion.

Improves Soil Structure: Prevents compaction, enhances aeration, and supports root development.

Diversification & Cost Reduction: Staggers labor needs, reduces equipment costs, and optimizes resource use year-round.

Additional Technical Benefits of Natural Farming

Mixed cropping increases plant cover in off-seasons, reducing nitrate leaching and enhancing nutrient cycling.

Non-legume crops can reduce nitrogen leaching by up to 81%, depending on soil type and rainfall.

Legume crops fix atmospheric nitrogen, enhancing soil nitrogen availability and reducing the need for external fertilizers.

Combining legumes and non-legumes as catch crops can reduce N leaching by 48-82% and increase grain yields by up to 6%.

Cover crops improve soil bulk density, aggregate stability, organic matter content, and reduce compaction.

Additional benefits include reduced phosphorus loss, increased soil carbon and nitrogen content, and prevention of water acidification.

Conclusion

Natural farming represents a transformative shift towards sustainable agricultural systems, emphasizing ecological harmony, resource conservation, and farmer well-being. With India's diverse agro-climatic zones and rich heritage of indigenous knowledge, there is significant potential to scale up natural farming practices—especially in fruit and vegetable crops—while integrating them with modern agroecological innovations. By fostering soil health, biodiversity, and economic resilience, natural farming can serve as a cornerstone of climate-resilient, profitable, and environmentally sound horticultural production for future generations.

Natural farming is emerging as a viable and sustainable alternative to conventional agriculture, offering benefits such as improved soil health, reduced input costs, and enhanced crop quality. India’s diverse agro-climatic zones and rich traditional knowledge base make it well-positioned to expand organic and natural farming practices, especially in fruit and vegetable crops. Integrating indigenous practices with modern ecological approaches can create profitable, environmentally friendly farming systems that also offer psychological and social benefits for farmers. Continuous research and skill development will be essential for maximizing the potential of natural farming in horticulture.

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