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Natural Farming: A Sustainable Approach for Enhancing Soil Health and Productivity in Mulberry Based Sericulture

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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Abstract

Natural farming has emerged as a sustainable agricultural approach that focuses on reducing dependence on synthetic inputs while improving soil health and long-term productivity. This review paper highlights the importance of natural farming as an eco-friendly strategy for enhancing soil fertility and sustainability in mulberry-based sericulture systems. It discusses the fundamental concept, aims, principles and scope of natural farming along with its key pillars that promote soil biological activity, nutrient recycling and ecological balance. The role of natural farming practices in improving soil health indicators such as organic matter content, microbial population and nutrient availability is emphasized. Special attention is given to the application of natural farming in mulberry cultivation where improved soil quality can lead to better leaf yield and quality, ultimately benefiting silkworm growth and cocoon production. The review also addresses the potential economic benefits through reduced input costs, along with government initiatives supporting natural farming adoption. In addition, existing risks, challenges and constraints in implementation are discussed and future prospects are outlined to encourage wider adoption of natural farming for sustainable mulberry cultivation and resilient sericulture production systems.

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Keywords: Natural farming; mulberry; soil health; Jeevamrutha; Beejamrutha; sericulture sustainability; ZBNF.

1. Introduction

Mulberry (*Morus alba* L.) serves as the primary and exclusive food source for the silkworm, *Bombyx mori* L.; consequently, its cultivation for the production of high-quality foliage is fundamental to the production of superior silk. The growth performance and economic traits of silkworms are largely determined by the nutritional quality of the mulberry leaves on which they feed (Krishnaswami et al., 1971). To achieve optimal leaf yield and quality, the recommended nutrient input for improved mulberry varieties such as V1 is 350:140:140 kg NPK ha^{-1} yr^{-1}, which supports leaf production exceeding 60 MT ha^{-1} $year^{-1}$. However, the intensive application of chemical fertilisers in agriculture and sericulture has contributed to environmental degradation, including soil and water pollution, and poses risks to human health (Kaushik et al., 2025; Bouyoucos, 1962). In addition, the rising cost of chemical inputs has become a significant constraint on sustainable production. In mulberry-based sericulture systems, approximately 60% of the total cost of cocoon production is attributed to mulberry leaf cultivation alone (Babu et al., 2011). Therefore, there is a pressing need to develop alternative and sustainable cultivation strategies that optimise nutrient management while reducing production costs.

Sustainable mulberry leaf production can be achieved through organic cultivation (Babu et al., 2012; Yadav *et al.*, 2020a) without reduction in yield and quality. Organic farming in mulberry has greatly influenced on the soil microbial activity and health (Berger & Truog, 1939; Bora et al., 2025; Venu et al., 2019). Adoption of absolute organic farming as an alternative method of mulberry cultivation in lieu of chemical based farming for sustained quality production have an advantage on soil fertility improvement. The effect of different organic inputs viz., FYM, Compost, Vermicompost, Green manuring etc. on growth and yield of mulberry are well documented. The role of farm yard manure (FYM) for mulberry leaf yield was well studied. Similarly, the influence of compost and vermicompost in mulberry were also revealed a positive effect on its growth and yield (Sudhakar et al. 2018). Green manuring in mulberry is recommended to improve the soil fertility status and higher leaf yield with reduced application of nitrogenous chemical fertilizers.

Studies revealed that application of nitrogenous and phosphatic bio fertilizers in mulberry garden can curtail the use of 50 % of chemical fertilizers for nitrogen and phosphorus respectively (Das *et al.*, 1994b; Das *et al.*, 1996). Dual inoculation of different biofertilizers of fungal and bacterial origin viz., Vesicular Arbuscular Mycorrhyza (VAM), Azotobacter in mulberry garden improve the rhizosphere microflora and plant growth (Bagyaraj & Menge, 1978; Katiyar *et al.*, 1995). Hence, it is well established that organic farming in mulberry can sustain its yield and quality placing the sericulture a sustainable enterprise.

Mulberry stands in a unique place for its high biomass production where in leaf alone contribute about 60 MT/ha/year along with an equal quantity of shoot in the present cultivable system followed in sericulture sector. Because of its potential for the high biomass production, its capacity for capturing and storing the atmospheric carbon is also records a significant importance. Kar *et al*., (2018) studied the carbon sequestration potential in mulberry and observed that 6.9 MT/ha/yr carbons can be sequestrated by S1635 variety in a farming practice with moderate tillage with grass cover. In the case of improved V1 mulberry variety it can sequester 15.1 MT/ha/year when it is cultivated with a farming system where reduced tillage with mulching and drip system of irrigation (Yadav *et al.*, 2020b). Mulberry trees are good carbon sink plants. It is estimated that 1 mμ mulberry tree is able to absorb about 41262 kg of carbon dioxide and release 3064 kg of oxygen each and every year (Deepa *et al.*, 2020). Mulberry presents alluring prospects in terms of soil carbon sequestration.

Zero Budget Natural Farming (ZBNF) was initially promoted by the agriculturist Subhash Palekar in the mid-1990s. It is regarded as a cost-reducing agricultural approach that minimises reliance on external inputs by substituting synthetic fertilisers and pesticides with locally prepared formulations such as Jeevamritha, Beejamritha, and Neemastra, alongside practices including intercropping and mulching (Palekar, 2005). ZBNF has been proposed as a viable strategy for enhancing food security through the promotion of environmentally sustainable agricultural practices, while simultaneously alleviating farmer indebtedness (Shivani & Sumit, 2021). In contrast, conventional agricultural methods, characterised by intensive chemical input use, have been associated with soil degradation, reduced fertility, and adverse health outcomes, thereby contributing to economic stress among farmers (Badwal et al., 2019). Empirical studies indicate that the adoption of ZBNF practices can lead to improvements in crop yield, soil fertility, seed diversity, and product quality over time, while also enhancing household food security, farm income, and overall health outcomes (Mohanapure & Chavhan, 2020). Furthermore, residue-free farming has been suggested as an intermediate approach between organic and conventional systems, offering the potential to mitigate environmental degradation without compromising productivity or economic returns. Transitioning to ZBNF may also reduce the fiscal burden associated with fertiliser subsidies, while facilitating the production of chemical-free food for consumers (Niti et al., 2020). Additionally, ZBNF contributes to cost reduction by eliminating external inputs and promoting the utilisation of on-farm resources to restore soil health. It also supports increased farm income, ecological sustainability, and climate resilience through the adoption of diversified and multi-layered cropping systems (Manida & Nedumaran, 2021).

Considering the economic and environmental challenges associated with conventional mulberry cultivation, natural farming offers a promising pathway to sustain soil health, ensure quality leaf production and strengthen the sustainability of mulberry-based sericulture systems.

2. Concept of Natural Farming

Natural farming is an agricultural approach that eliminates the use of synthetic chemical inputs and instead relies on ecologically integrated and diversified farming systems. Rooted in agroecological principles, it incorporates the integration of crops, trees, and livestock to optimise resource use efficiency and enhance system resilience. This approach maximises the utilisation of functional biodiversity and emphasises the use of on-farm inputs prepared by farmers themselves. Within natural farming systems, indigenous cattle breeds, particularly desi cows, play a pivotal role. Their dung and urine are utilised in the preparation of various bio-formulations that stimulate and support natural biological and ecological processes within the farm ecosystem (Palekar, 2005). This approach is closely associated with low-disturbance or no-tillage farming practices, which were first introduced in Japan in the 1940s and have since gained global recognition as a sustainable strategy for restoring ecological balance and improving soil health.

2.1 Aims and Objectives of Natural Farming

- Preserve natural flora and fauna
- Restore soil health, fertility and soil’s biological life
- Maintain diversity in crop production
- Efficient utilization of land and natural resources (light, air, water)
- Promote natural beneficial insects, animals and microbes in soil for nutrient recycling and biological control of pests and diseases
- Promotion of local breeds for livestock integration
- Use of natural / local resource-based inputs
- Reduce input cost of agricultural production
- Improve economics of farmers

2.2 Principles of Natural Farming

The principles of natural farming were developed by Subhash Palekar who is popularly known as ‘Krishi ka Rishi’ and also ‘Father of zero/low budget natural farming’ (Palekar, 2005).

a. Natural inputs: Toxic free, freely available resources in nature
b. Low inputs: No use of chemicals and fertilizers, promotes natural catalyst of biological processes in the soil and natural protection from diseases
c. Mulching: Soil protection, creates conductive environment for biological processes in the soil
d. Multiple cropping: Minimizes the risk of crop failure, continuity of income source

2.3 Scope and Importance of Natural Farming

Natural farming represents a sustainable agricultural approach aimed at enhancing soil fertility while promoting environmental health. By minimising reliance on synthetic inputs, this system not only supports agricultural productivity but also contributes to climate change mitigation. Practices such as composting, crop rotation, and agroforestry facilitate carbon sequestration in the soil, thereby improving nutrient availability for plants and strengthening overall soil quality. These processes also enhance ecosystem resilience and stability.

Furthermore, the reduced use of synthetic fertilisers and pesticides contributes to improved food safety and water quality by minimising agricultural runoff and associated health risks. From an economic perspective, natural farming can increase farm profitability by lowering input costs and enabling access to markets for sustainably produced commodities. In addition, it has the potential to generate employment opportunities in rural areas, thereby supporting local economies and reducing rural outmigration. Overall, natural farming offers a holistic and sustainable solution to contemporary agricultural challenges, including food insecurity and rural poverty, while fostering a more equitable and resilient food production system.

Table 1. Difference between conventional, organic and natural farming (Palekar, 2005; Babu et al., 2012)

Aspect	Conventional farming	Organic farming	Natural farming
Basic concept	Focuses on maximizing yield using chemical inputs	Avoids synthetic chemicals; uses organic inputs	No external inputs
Fertilizers	Chemical fertilizers (Urea, DAP, MOP etc.)	Organic manures, compost, vermicompost, green manure	On-farm inputs like Jeevamrit, Beejamrit, ghan-jeevamrit
Pest & disease management	Synthetic pesticides, insecticides, fungicides	Biopesticides, botanicals, biological control	Indigenous preparations (neem, cow-based formulations, botanical extracts) Agniastra, Bramhastra, Neemastra and Dashparni ark
Soil health	Often deteriorates soil structure and microbial activity	Improves soil organic matter and microbial diversity	Enhances soil life and natural nutrient cycling
Seed treatment	Chemical seed treatment	Biological or organic seed treatment	Beejamrita and natural seed treatments
Weed management	Chemical herbicides	Mechanical and cultural methods	Mulching, intercropping, manual weeding
Input cost	High	Moderate to high	Very low
Yield	High in short term	Slightly lower initially, stable long-term	Comparable in long term after transition
Environmental impact	Causes pollution and biodiversity loss	Eco-friendly and sustainable	Highly eco-friendly, regenerative
Residues in produce	Chemical residues possible	Residue-free	Completely chemical-free
Farmer dependency	High dependency on external inputs	Partial dependency on certified organic inputs	Self-reliant, uses farm-based resources
Certification	Not required	Required for organic labelling	Usually not mandatory (region-specific)
Sustainability	Low in long term	High	Very high

3. Key Components and Practices of Natural Farming

Natural farming practices are mainly based on four key components known as the four pillars of Zero Budget Natural Farming (ZBNF) proposed by Subhash Palekar. These pillars include Beejamrita, Jeevamrutha, Acchadana (Mulching) and Whapasa, which together improve soil biological activity, nutrient availability and crop productivity.

3.1 Pillars of Natural Farming

3.1.1 Beejamrita

Beejamrita is a microbial seed treatment prepared using fresh cow dung, cow urine, virgin soil, calcium chloride and water (Palekar, 2005). Seeds are coated with this mixture before sowing to protect them from soil- and seed-borne pathogens. It enhances seed germination, seedling vigour and root growth by introducing beneficial microorganisms (Mukherjee et al., 2022). Cow dung naturally contains useful microbes ((Banerjee *et al*., 2023), and seed treatment with Beejamrita also promotes the production of plant growth regulators such as IAA and GA (Sreenivasa et al., 2009).

3.1.2 Jeevamrutha

Jeevamrutha is a fermented microbial culture prepared from cow dung, cow urine, jaggery, pulse flour, water and a small quantity of fertile soil. The mixture is fermented for 2-4 days and applied to soil or through irrigation water. It acts as a catalyst that stimulates microbial activity, improves nutrient availability and enhances crop growth and yield (Boraiah et al., 2017a; Santosha Gowda et al., 2021). Solid Ghana Jeevamrutha is also prepared using cow dung, jaggery and pulse flour for soil application.

Table 2. Nutrients concentration in natural farming inputs (Choudhary *et al.*, 2022)

Sl. No.	Input	N %	P %	K %
1	Beejamrit	0.72	0.14	0.23
2	Jeevamrit	0.25	0.13	0.16
3	Ghanajeevamrit	1.05	0.87	0.68

3.1.3 Whapasa

Whapasa refers to the ideal soil condition where air and water are present in balanced proportions in the root zone. Natural farming promotes this condition through minimal irrigation, reduced tillage and improved soil organic matter. Efficient water management through micro-irrigation systems such as drip or sprinkler irrigation helps maintain this balance and improves soil-water-plant relations.

3.1.4 Mulching / Acchadana

Acchadana refers to covering the soil with crop residues or cover crops to conserve moisture, suppress weeds and improve soil fertility. Types of mulching include soil mulching, straw mulching and live mulching with legumes. Generally, 5-7 t ha^{-1} of crop residues are used for effective soil cover. Mulching enhances soil organic matter and improves nutrient cycling in natural farming systems.

3.2 Plant Protection in Natural farming

Natural farming promotes the use of botanical extracts (kashaya or decoctions) prepared from locally available materials such as cow urine, neem leaves, green chilli, garlic, tobacco and sour buttermilk. These preparations act as natural fungicides and insecticides and help manage pests without using synthetic chemicals. Common formulations recommended under natural farming include Agniastra, Brahmastra, Neemastra and Dashparni Ark (Palekar, 2005). Prophylactic spraying of these botanical formulations at 15-30 day intervals depending on crop condition helps in preventing pest and disease incidence.

3.2.1 Agniastra

Agniastra is prepared by mixing 20 L of cow urine with crushed tobacco (500 g), green chilli (0.5 kg), garlic (0.25 kg) and neem leaves (5 kg). The mixture is boiled, cooled and fermented for about 48 hours, then filtered before use. It is effective against pests such as leaf rollers, stem borers, fruit borers and pod borers. About 6–8 L of Agniastra is diluted in 200 L of water and sprayed for one acre crop. The solution can be stored for up to three months.

3.2.2 Brahmastra

Brahmastra is prepared using 10 L of cow urine mixed with crushed leaves of neem, pongamia (karanj), custard apple, castor and datura (about 2 kg each). The mixture is boiled, filtered and fermented for 48 hours in shade. It is sprayed at 6-8 L per 200 L water per acre and helps control sucking pests, fruit borers and pod borers. The prepared solution should preferably be used within one month.

3.2.3 Neemastra

Neemastra is prepared by mixing 5 L cow urine, 1 kg fresh cow dung and 5 kg neem leaf paste in 100 L of water. The mixture is fermented for 48-96 hours with periodic stirring and then filtered.

It is effective against sucking pests and leaf-eating caterpillars, and the prepared solution is generally sufficient for one acre.

3.2.4 Dashparni Ark

Dashparni Ark is a botanical extract prepared using cow urine, cow dung and leaves of ten medicinal plants such as neem, karanj, castor, custard apple, bael, marigold, tulsi, datura, mango and aak. Additional ingredients like turmeric, ginger, garlic, chilli and tobacco are added to enhance pesticidal properties. The mixture is fermented for 30-40 days with regular stirring. For spraying, 6-8 L of extract is diluted in 200 L of water per acre and used to control borers, caterpillars and maggots.

4. Impact of Natural Farming on Soil health

Natural farming improves soil health by increasing organic matter, microbial activity and nutrient cycling compared to conventional systems. These improvements enhance soil structure, fertility and biological activity, which support sustainable crop production and mulberry-based sericulture.

4.1 Physical Properties

Natural farming improves soil structure by increasing stable aggregates and organic matter, thereby reducing bulk density and improving porosity and water-holding capacity. Choudhary et al. (2022) reported a reduction in bulk density from 1.45 to 1.28 g cm^{-3} and a 20-40% increase in soil porosity, while water-holding capacity increased by 15-25% due to higher soil organic carbon (0.71% vs. 0.42% in conventional systems). In mulberry gardens, deep-rooted plants and cover crops such as dhaincha enhance soil infiltration (up to 50 mm hr^{-1}) and reduce erosion under rainfed conditions (Vaja *et al*., 2024).

4.2 Chemical Properties

Natural farming inputs help stabilize soil pH, reduce electrical conductivity and enhance nutrient availability through microbial mineralization. Choudhary et al. (2022) reported that soil pH under natural farming stabilized at 6.8-7.2, while electrical conductivity decreased to 0.25 dS m^{-1}. Available nutrients increased significantly with nitrogen (275 kg ha^{-1}), phosphorus (17.6 kg ha^{-1}) and potassium (293.5 kg ha^{-1}) following Jeevamrutha application. Mulberry trials also recorded 15-25% higher soil organic matter and improved exchangeable Ca and Mg, supporting better leaf quality.

4.3 Biological Properties

Natural farming promotes a diverse microbial ecosystem that enhances nutrient cycling and soil fertility. Beneficial microbes such as nitrogen-fixers, phosphate-solubilizers and mycorrhizae increase significantly. Kamal and Ravi (2025) reported 20-40 % higher microbial biomass carbon, with bacterial counts of 28.3×10^6 CFU g^{-1}, actinomycetes 22.0×10^5 CFU g^{-1} and fungi 8.5×10^3 CFU g^{-1}, along with higher enzyme activities. Earthworm populations also increased by 25-30 %, improving soil aeration and nutrient cycling.

5. Effect of Natural Farming on Crop Growth and Yield

Natural farming can improve crop growth and yield by enhancing soil fertility, moisture retention and biological activity, while reducing production costs.

5.1 Field Crops

Field studies show varied yield responses depending on crop type and management. Duddigan et al. (2023) reported higher yields in groundnut and tomato under Zero Budget Natural Farming (ZBNF) compared with conventional and organic systems in South India. Similarly, Kumar et al. (2023) observed yields comparable to conventional farming in Andhra Pradesh, Karnataka and Maharashtra, particularly in low-input crops such as finger millet, with improved profitability due to reduced input costs. However, Malakannavar et al. (2024) reported yield reductions of 23.5 % in green gram and 74.5 % in paddy under natural farming, indicating that crops with lower nutrient demand perform better. The study suggested that integrating farmyard manure and other organic sources can improve yields under natural farming systems. The study also documented 33.38 % and 30.23 % weed control efficiency through mulching in green gram and paddy, respectively.

5.2 Horticultural Crops

Natural farming practices have shown positive effects on growth and yield in several horticultural crops due to improved soil fertility, microbial activity and botanical pest management. Boraiah et al. (2017b) reported that bell pepper yield increased by 28 % (3.1 t ha^{-1}) under natural farming compared with 2.4 t ha^{-1} in conventional systems, along with 35 % lower thrips incidence and improved plant vigor. Similarly, Galab et al. (2019) observed 18 % higher gram yields and 22 % greater banana bunch weight in ZBNF farms in Andhra Pradesh due to improved nutrient cycling through mulching.

Korav et al. (2020) also reported yield advantages of about 35 % in tomato and improved drought tolerance in cotton under ZBNF practices. In chilli, Karale et al. (2020) recorded 25 % higher fruit yield (2.8 t ha^{-1}) and increased plant growth due to Jeevamrutha application and mulching. Likewise, NAARM-CRIDA (2020) demonstrated through soybean-maize intercropping trials under natural farming that green cob yields reached 3719-3836 kg/ha (vs. 2850 kg/ha in conventional systems), with NPK uptake elevated by 32 % (N: 145 kg/ha), 28 % (P: 22 kg/ha) and 25 % (K: 180 kg/ha) due to microbial solubilization.

5.3 Plantation Crops

Natural farming practices have also been evaluated in plantation crops. Pilot trials in coconut and arecanut plantations integrating ZBNF practices such as Jeevamrutha and mulching showed 20-30 % reduction in input costs, while maintaining yields comparable to conventional systems (4.5-5.2 t ha^{-1}). Soil microbial populations also increased by about 35%, indicating improved soil health.

Similarly, NAARM-CRIDA (2020) reported that mulching in rubber plantations improved drought tolerance by 20-25% and maintained latex yield at 1.8 t ha^{-1}, mainly due to increased soil organic carbon and improved soil moisture retention.

6. Economic Analysis of Natural Farming

Natural farming (NF), particularly Zero Budget Natural Farming (ZBNF), has emerged as a low-input and economically viable agricultural production system. The approach emphasizes the use of locally available biological resources such as cow dung, cow urine, crop residues and botanical extracts, thereby minimizing the dependence on external chemical inputs. Several empirical studies conducted across different agro-ecological regions of India have demonstrated that natural farming significantly reduces the cost of cultivation while maintaining comparable crop yields, ultimately improving farm profitability and economic sustainability (Khadse et al., 2017; Kumar et al., 2023). The major economic advantages of natural farming are discussed below.

6.1 Reduction in Cost of Cultivation

One of the most significant economic benefits of natural farming is the substantial reduction in cultivation costs, as it replaces costly chemical fertilizers, pesticides, and synthetic growth regulators with locally available biological inputs like cow dung, cow urine, botanical extracts, and crop residues. This significantly reduces farmers' expenditure on agricultural inputs.

Field studies conducted in Andhra Pradesh Community Managed Natural Farming (APCNF) programs revealed that cultivation costs under natural farming were ₹3,000-₹22,000 per acre lower compared with conventional chemical farming systems (Khadse et al., 2017). In rice cultivation, farmers practicing natural farming reported an average expenditure of ₹846 per acre on inputs, whereas farmers following conventional chemical-based practices spent approximately ₹5,961 per acre. Overall, farmers adopting community-based natural farming systems recorded nearly 44 % reduction in input costs, which substantially improved their economic returns and reduced dependence on external chemical inputs (Galab et al., 2019).

6.2 Net Income and Farm Profitability

In rainfed agricultural systems, natural farming practices have been reported to increase net farm income by nearly 50 % compared with conventional farming systems (Kumar et al., 2023). Similarly, studies conducted under community-managed natural farming programs reported net revenue increases ranging from ₹9,000 to ₹37,000 per acre, primarily due to the elimination of chemical fertilizers and pesticides (Khadse et al., 2017). Farmers participating in community natural farming programs also recorded approximately 28 % higher gross income per hectare, demonstrating the economic viability of natural farming systems (Galab et al., 2019).

6.3 Savings in Fertilizer Subsidies and Resource Use

Apart from farm-level economic benefits, natural farming also offers significant economic advantages at regional and national levels by reducing fertilizer subsidies and conserving natural resources. Since natural farming eliminates the use of synthetic fertilizers, large-scale adoption can significantly reduce government expenditure on fertilizer subsidies.

Economic assessments indicate that widespread adoption of natural farming in Andhra Pradesh alone could potentially save about ₹2,100 crore annually in fertilizer subsidy expenditure (Khadse et al., 2017). Furthermore, natural farming practices improve resource-use efficiency by reducing irrigation requirements, electricity consumption and energy inputs associated with fertilizer production and application. These benefits contribute to long-term economic sustainability and resource conservation.

6.4 Economic Benefits through Crop Diversification

Studies conducted under community natural farming programs reported that farmers practicing natural farming cultivated an average of four crops per farm, compared with only two crops under conventional monocropping systems (Galab et al., 2019). Crop diversification not only improves farm income stability but also enhances soil fertility and ecosystem resilience through improved biodiversity and nutrient cycling.

6.5 Long Term Economic Stability

Natural farming contributes to long-term economic sustainability by improving soil fertility, enhancing biodiversity and restoring ecosystem services. Long-term ecological farming studies have shown that improvements in soil organic carbon, microbial biomass and nutrient cycling result in sustained productivity and profitability over time (Duddigan et al., 2023).

Improved soil health under natural farming systems reduces the need for external inputs in subsequent cropping cycles, thereby lowering production costs and improving farm resilience. These benefits make natural farming a sustainable agricultural approach capable of maintaining farm income while conserving natural resources and environmental quality.

7. Schemes and Government Initiatives Supporting Natural Farming in India

In recent years, the Government of India and several state governments have introduced various policy initiatives and programs to promote natural farming as a sustainable agricultural production system. These initiatives aim to reduce farmers' dependence on chemical fertilizers and pesticides while improving soil health, biodiversity and farm profitability.

Government interventions primarily focus on capacity building, financial incentives, establishment of bio-input resource centres, cluster-based implementation and certification support. At the national level, programs such as Bharatiya Prakritik Krishi Paddhati (BPKP) under the Paramparagat Krishi Vikas Yojana (PKVY) and the National Mission on Natural Farming (NMNF) have been introduced to promote large-scale adoption of natural farming practices.

In addition to national initiatives, several states have implemented large-scale natural farming programs. For example, the Andhra Pradesh Community Managed Natural Farming (APCNF) program has emerged as one of the world's largest agroecological transition initiatives, promoting ZBNF practices among millions of farmers. Similarly, states such as Himachal Pradesh, Rajasthan, Gujarat and Sikkim have introduced policy initiatives to support natural farming through farmer training, input support and market linkages.

These policy interventions play a crucial role in scaling up natural farming adoption by strengthening institutional support, enhancing farmer awareness and creating sustainable agricultural value chains. The major national and state-level schemes supporting natural farming in India are summarized in Table 3.

8. Constraints and Challenges

a. Low awareness and technical knowledge: Many farmers lack adequate understanding of natural farming principles, preparation of bio-inputs (e.g., Jeevamrutha, Beejamrutha) and their proper field application.
b. Initial yield reduction: Crop yields may decline during the transition phase from conventional to natural farming due to changes in soil nutrient availability and reduced use of external inputs.
c. Time required for soil restoration: Improvements in soil fertility, microbial activity, and ecological balance occur gradually, requiring long-term commitment from farmers.
d. Labour-intensive practices: Preparation and application of natural inputs such as Jeevamrutha, botanical extracts, and mulching require considerable labour and time.
e. Limited availability of indigenous inputs: Availability of desi cow dung, cow urine, plant biomass, and other organic materials may be insufficient, particularly for farmers with large landholdings.
f. Complex pest and disease management: Natural plant protection measures often act slowly and may be less effective during severe pest or disease outbreaks.
g. Limited scientific validation: In several regions, crop- and location-specific research data on natural farming practices are limited, which may reduce farmer confidence and policy support.
h. Nutrient management challenges: Meeting the nutrient requirements of high-yielding or intensive crops using only natural inputs can be difficult.
i. Weak extension and advisory services: Lack of sufficient training programs, demonstrations, and technical guidance restricts large-scale adoption.
j. Market and price uncertainty: Absence of dedicated markets, value chains, and premium pricing for natural farming produce discourages farmers from adopting the system.
k. Certification and standardization issues: Natural farming lacks universally accepted certification systems compared to organic farming, which affects market credibility and consumer trust.
l. Risk perception among farmers: Farmers often perceive natural farming as risky due to uncertainty in yield, market access, and technical knowledge during the transition period.

Table 3. Schemes and government initiatives supporting natural farming in India

Scheme/ Program	Launch year	Implementing agency	Key features	Budget/Target	Status (as of 2026)
National Mission on Natural Farming (NMNF)	2023-24 (independent scheme)	Ministry of Agriculture & Farmers Welfare of India	Promotion of natural farming through 15,000 clusters covering 7.5 lakh ha; establishment of 10,000 Bio-Input Resource Centres (BRCs); financial incentive of ₹4,000 per acre per year for 2 years; PGS-India certification and Krishi Sakhi training programmes	₹2,481 crore (₹1,584 Cr Central share + ₹897 Cr State share); target of 1 crore farmers	Operational guidelines issued in December 2024; about 70,021 Krishi Sakhis trained; implementation initiated in FY 2025
Bharatiya Prakritik Krishi Paddhati (BPKP)	2020 (pilot phase)	Ministry of Agriculture under Paramparagat Krishi Vikas Yojana (PKVY)	Pilot implementation in 7 states (AP, HP, Kerala, MP, Rajasthan, UP, Chattisgarh); Promotion of Jeevamrita and cow-based bio-inputs; cluster based approach	Implemented under PKVY budget of ₹2,170 crore	Pilot phase completed and later integrated into NMNF; initially covered about 1.5 lakh ha
Paramparagat Krishi Vikas Yojana (PKVY)	2015-16	Ministry of Agriculture & Farmers welfare	Promotion of organic and natural farming clusters; Participatory Guarantee system (PGS) certification; financial support of Rs. 50,000 per ha over three years	Total allocation about ₹2,170 crore (till 2023)	Over 6.43 lakh ha certified organic area; continues to support the transition towards natural farming
Andhra Pradesh Community Managed Natural Farming (APCNF/ APZBNF)	2016	Rythu Sadhikara Samstha (RySS), Govt. of Andhra Pradesh	Large scale natural farming model with peer-to-peer farmer learning, cow based inputs, and climate resilient practices	State supported programme	More than 8 lakh farmers practicing natural farming covering about 6 lakh ha; input costs reduced by 50 %
Sikkim Organic Mission	2010	Govt. of Sikkim	Comprehensive initiative to convert agriculture to organic and natural systems; elimination of chemical fertilizers and pesticides	State government funded	Achieved 100 % organic state status in 2016; serves as a national model for ecological agriculture
Rajasthan Natural Farming	2021	Department of	Promotion of natural farming	Target area of 36,000 ha	Around 15,000 farmers

Scheme/ Program	**Launch year**	**Implementing agency**	**Key features**	**Budget/Target**	**Status (as of 2026)**
Initiative		Agriculture, Government of Rajasthan	through farmer training programmes; cluster approach and Bio-Input Resource Centres		covered by 2025
Himachal Pradesh Natural Farming Scheme (Prakritik Kheti Khushhal Kisan Yojana)	2021	Himachal Pradesh Organic Mission	Promotion of chemical free farming through Kisan Mitra training, cow-based inputs, and farmer field schools	Approx. ₹100 crore state allocation	Around 50,000 farmers covered by 2025

9. Research Gaps and Future Perspectives

Research gaps:

- Long-term field trials: There is a lack of multi-year studies evaluating yield stability, soil health recovery, and silkworm productivity under natural farming practices in both rainfed and irrigated mulberry ecosystems.
- Economic evaluation: Limited research is available on transition-phase costs, bio-input efficiency, and return on investment (ROI) in terms of mulberry leaf yield, cocoon quality, and overall farm profitability compared with conventional systems.
- Pest and disease dynamics: Insufficient information exists on pest population dynamics, disease incidence, and development of resistant mulberry varieties under chemical-free natural farming conditions.
- Soil microbial ecology: More studies are needed to understand rhizosphere microbial shifts under natural farming and their influence on nutrient availability, leaf quality, and silkworm performance.
- Scalable cropping models: Research on validated intercropping and diversified farming models that maintain mulberry leaf quality and tenderness while improving soil health and farm income is limited.

Future prospects:

- Development of resilient mulberry varieties: Breeding climate-resilient and nutrient-efficient mulberry varieties suitable for natural farming systems, integrated with precision technologies such as soil moisture and nutrient sensors.
- Circular bio-economy approaches: Utilization of sericulture by-products such as mulberry prunings, silkworm litter, and rearing waste for the production of bio-fertilizers, compost, and value-added products like silk-based biomaterials.
- Policy support and scaling up: Expansion of initiatives such as the National Mission on Natural Farming (NMNF) through Farmer Producer Organizations (FPOs), certification support, and market linkages to enhance farmer income and adoption.
- Digital and smart farming integration: Use of digital technologies, IoT-based monitoring systems, and mobile advisory platforms to optimize mulberry garden management and silkworm rearing conditions under natural farming.
- Integrated farming systems: Development of holistic agro-ecological models combining mulberry cultivation with livestock, apiculture, and agroforestry to enhance biodiversity, farm resilience, and diversified income.

10. Conclusion

Sustainable production of high quality mulberry leaf is fundamental to maintain consistent cocoon yield and silk quality in mulberry-based sericulture. However, the continued reliance on chemical-intensive cultivation has increased production costs and adversely affected soil fertility over time, thereby threatening long-term productivity. Although organic farming offers an ecofriendly alternative, its higher cost and limited availability restrict its adoption on a large scale. Mulberry is a perennial crop with high biomass production and nearly 50 % of the generated shoot biomass remains underutilized, often being discarded without proper recycling. Natural farming provides an effective and low-cost solution by promoting on-farm recycling of crop residues, use of locally available bio-inputs, and reduced dependence on external chemical inputs. These practices improve soil fertility, enhance microbial activity, and support long-term sustainability of mulberry cultivation. Therefore, the integration of natural farming practices in mulberry cultivation can ensure sustained production of quality leaves, reduced cost of cultivation, improved soil health and sustainable sericulture, eventually improving the security of farmers' livelihoods who practice mulberry-based sericulture.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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