



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; SP-9(5): 389-393
Received: 18-02-2026
Accepted: 26-03-2026

Jince Mary M Joy
On Farm Research Centre,
Onattukara Regional Agricultural
Research Station, Kerala
Agricultural University,
Kayamkulam, Alappuzha, Kerala,
India

Jacob D
On Farm Research Centre,
Onattukara Regional Agricultural
Research Station, Kerala
Agricultural University,
Kayamkulam, Alappuzha, Kerala,
India

Juttu Ravinder
Department of Soil Science and
Agricultural Chemistry,
Agricultural College, Polasa,
Professor Jayashankar Telangana
Agricultural University, Jagtial,
Telangana, India

Triptesh Mondal
Department of Agronomy and
Agroforestry, M.S. Swaminathan
School of Agriculture, Centurion
University of Technology and
Management Paralakhemundi,
Odisha, India

Corresponding Author:

Jince Mary M Joy
On Farm Research Centre,
Onattukara Regional Agricultural
Research Station, Kerala
Agricultural University,
Kayamkulam, Alappuzha, Kerala,
India

Performance of cropping systems under natural farming in India

Jince Mary M Joy, Jacob D, Juttu Ravinder and Triptesh Mondal

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i5Se.5597>

Abstract

Natural farming has emerged as a viable agroecological alternative to conventional, input-intensive agriculture in India, offering potential solutions to challenges such as declining soil fertility, escalating input costs, and climate-induced stress. Rooted in agroecological principles and indigenous knowledge, natural farming minimizes external inputs by relying on biological processes, on-farm resources, and traditional cropping practices. This review synthesizes scientific evidence on the performance of natural farming across diverse Indian cropping systems. Results suggest that natural farming not only reduces the cost of cultivation but also enhances soil health, making it particularly relevant for small and marginal farmers. However, systematic research on long-term productivity, nutrient dynamics, and scalability across diverse agro-climatic zones remains limited. The paper also identifies knowledge gaps and suggests research directions for the sustainable integration of natural farming into India's agricultural landscape.

Keywords: Cropping systems, productivity, profitability, soil health, sustainable agriculture

Introduction

Agriculture remains the backbone of India's economy, sustaining nearly 58% of the population and contributing significantly to the nation's GDP. The Green Revolution of the 1960s brought self-sufficiency in food grain production through high-yielding varieties, chemical fertilizers, pesticides, and irrigation. However, this chemically intensive model has also triggered long-term ecological and socio-economic consequences like declining soil fertility, groundwater depletion, rising input costs, biodiversity loss, and increased vulnerability of small and marginal farmers (Sebby, 2010, Pingali, 2012, Eliazar *et al* 2019) ^[24, 19, 11]. Many farmers today are grappling with rising input costs, uncertain weather patterns, and diminishing returns. In this backdrop, natural farming has emerged as a promising agroecological alternative that seeks to restore ecological balance, reduce farmers' dependency on costly inputs, and build resilience against climate variability.

The Ministry of Agriculture and Farmers' Welfare defined natural farming as a chemical free natural farming system where-in use of low-cost inputs (cow dung/urine and plant extract based) coupled with recommended agronomic practices like mulching and intercropping are promoted. Natural farming is a traditional, chemical-free approach rooted in agroecological principles, characterized by a diversified farming system that integrates crops, trees, and livestock while promoting functional biodiversity (De LC 2022) ^[8]. It focuses on the synergistic interactions between plant- and animal-derived inputs to enhance crop performance, sustain soil fertility, and support beneficial soil microbial communities (Smith *et al* 2020) ^[27].

Crops cultivated under natural farming typically contain minimal chemical contaminants, and the use of farm-based amendments has been shown to enhance food safety and nutritional quality (Bharucha and Mitjans 2020) ^[3]. Studies have documented higher levels of antioxidants and essential minerals such as potassium, phosphorus, magnesium, zinc, iron, calcium, and copper in naturally grown produce (Baranski *et al* 2014). Moreover, natural farming significantly reduces production costs by eliminating the need for synthetic fertilizers and pesticides, making it economically viable for smallholder farmers (Korav *et al* 2020 and Duddigan *et al* 2022) ^[13, 9]. Agronomic practices such as crop rotation, green manuring, biological pest control, and animal integration further enhance soil fertility, reduce pest incidence, and promote sustainable intensification. Key inputs like *Jeevamrutha*, made from

locally available materials, play a vital role in rejuvenating soil health and microbial biodiversity (Duraivadivel *et al* 2022) ^[10]. The adoption of diverse and multi-seasonal cropping systems under natural farming not only optimizes land use but also reduces pest pressures and maintains ecological equilibrium.

In this context, there is a growing need to assess how natural farming performs across different cropping systems under varied agro-climatic conditions in India. While several studies have highlighted the potential benefits of natural farming, evidence remains fragmented. This review aims to consolidate and critically examine available research on the performance of cropping systems under natural farming, focusing on crop productivity, soil health, and economic viability. It also identifies key knowledge gaps and outlines directions for future research to guide the sustainable scaling of natural farming across India.

Effect of natural farming on productivity

Natural farming (NF), characterized by the use of on-farm biological inputs and the elimination of synthetic agrochemicals, has the potential to enhance sustainability. A growing body of research, particularly from ICAR and State Agricultural Universities (SAUs), provides valuable insights into system-specific productivity trends under NF. Suggested cropping systems suitable for natural farming based on ICAR Network research on Natural farming and studies made by SAUs is listed in Table 1. Indian Council of Agricultural Research through All India Network Programme on Organic Farming (AI-NPOF) with 20 co-operating centres in 16 states initiated multi-location trials to assess the performance of NF across various agroecologies and cropping systems. System productivity of crop/ crop combinations/cropping systems under natural and conventional farming systems at various locations is given in Table 2. Results show a mixed performance, with yield responses varying depending on the crop type, nutrient requirement, location, and agronomic management. Yield obtained under natural farming experiments over a period of two years indicate that yield of

legume (soybean/cowpea) and tuber (cassava) based cropping systems are either better or comparable with that of integrated crop management (Meena *et al* 2024) ^[17]. Yadav (2023) ^[31] reported that maximum system equivalent yield (7429 kg/ha) obtained in cowpea-fennel cropping system was higher by 43.91, 43.05 and 41.86 per cent over T₇ -(AI-NPOF) package, T₈ -[Integrated Crop Management (50% nutrient application through organic manures and 50% nutrient application through inorganic sources with use of *Neemaster*, *Agniaster* for pest management) and T₉ -[Integrated Crop Management (50% nutrient application through organic manures and 50% nutrient application through inorganic sources with application of need based pesticides for pest management)] respectively. Choudhary *et al* (2022) ^[5] found that a combination of *ghanjeevamrit*, *jeevamrit*, and mulching significantly enhanced productivity from 2226.40 kg/ha to 3552.91 kg/ha in wheat-gram intercropping systems under mid-hill conditions.

However, NF showed limitations in nutrient-intensive cropping systems, particularly those involving cereals like paddy and wheat. Malakannavar (2024) ^[16] observed a 74.49% yield decline in paddy and an 18.76% reduction in green gram under NF when compared to conventional systems. Similarly, Singh *et al* (2023) ^[26] reported considerable yield drops in rice - wheat + lentil (2247 kg/ha) when grown under natural farming as opposed to conventional farming (6083 kg/ha) attributing them to insufficient nutrient availability and higher weed competition in the absence of chemical inputs.

Despite yield reductions in certain systems, NF often results in comparable or higher system productivity in diversified and low-input cropping systems. especially when practices like intercropping and mulching are optimized. Ravisankar *et al* (2024) ^[22] highlighted that bio-concoctions, intercropping, and mulching enhanced yields by (7.8- 25.8%), (9.1- 67.7%), and (11- 25.7%) respectively depending on the crop combination. These practices contribute to soil moisture conservation, weed suppression, and improved root health ultimately enhancing overall productivity.

Table 1: Suggested cropping systems suitable for Natural farming based on ICAR Network research on Natural farming and studies made by SAUs.

	State	Cropping system
1	Chhattisgarh	Soybean + maize-wheat + mustard
2	Himachal Pradesh	Tomato + French Bean + Brinjal, Cucumber + French Bean + Okra, Pea + Spinach + Coriander, Cabbage + Fenugreek + Coriander, Soybean + maize - vegetable pea + coriander (green leaf)
3	Gujarat	Wheat + Chickpea, Maize + Soybean, Wheat + Lucerne, Groundnut + sesame, Pearl millet + Pulses, Castor + Green gram, Castor + Groundnut, Pigeon pea + groundnut, Turmeric + cowpea, Groundnut + Sesame-Fennel + Cabbage intercropping
4	Karnataka	Cotton + green gram – sorghum + chickpea, Cotton + Groundnut, Red gram + Groundnut, Red gram + Finger millet, Red gram+Fox tail millet, Red gram+ Barnyard millet, Ground nut + Finger millet, Ground nut + Kodo millet, and Ground nut + Brown top millet, Finger millet-field bean, Paddy –soybean, Finger millet – cowpea, Paddy – green gram, sugarcane + soybean, cotton + field bean etc.
5	Kerala	Cassava + vegetable cowpea-green gram, Turmeric + cowpea -greengram
6	Madhya Pradesh	Soybean + maize-wheat + mustard
7	Meghalaya	Turmeric + cowpea -greengram
8	Rajasthan	Groundnut + Sesame-, Fennel + Cabbage
9	Sikkim	Soybean + maize - vegetable pea + coriander (green leaf)
10	Tamil Nadu	Cotton + green gram– sorghum + chickpea
11	Uttarakhand	Soybean + maize - vegetable pea + coriander (green leaf)

Source: Bhavan (2025) ^[4].

Table 2: System productivity of crop/ crop combinations/cropping systems under natural and conventional farming systems at various locations

Cropping systems	Location	Productivity (kg ha ⁻¹)
Soybean + maize- vegetable pea + coriander (green leaf)	Himachal Pradesh, Uttarakhand, Sikkim	7307 (Soybean equivalent)
Soybean + maize-wheat + mustard	Madhya Pradesh, Chhattisgarh	4020 (Soybean equivalent)
Cowpea + maize- fennel + cauliflower/cabbage	Gujarat, Rajasthan	9473 (Cowpea equivalent)
Cassava + vegetable cowpea - green gram	Kerala	45050 (Cassava equivalent)
Turmeric + cowpea(1:1) - green gram	Meghalaya	12227 (Turmeric equivalent)
Cotton + green gram (1:1) - sorghum + chickpea (1:1)	Tamil Nadu, Karnataka	1692 (Cotton equivalent)
Rice + dhaincha - sorghum/maize + cowpea	Maharashtra, Jharkhand	5449 (Rice equivalent)
Maize + cowpea - wheat + chickpea	Uttar Pradesh, Punjab	4710 (Maize equivalent)

Source: Sharma *et al* (2023) ^[25]

Effect of natural farming on profitability

Beyond productivity, the economic viability of natural farming is a central concern influencing its adoption. Profitability in farming systems is shaped not only by yield levels but also by input costs, labor intensity, and access to markets for value-added produce. Better farm incomes through intercrops fringe

benefit in natural farming (Kumar *et al* 2020) ^[14]. A summary of profitability of various natural farming systems is presented in Table 3. These studies highlight that Natural farming can enhance profitability, especially in diversified and low-input cropping systems, primarily through reduced input costs and improved benefit–cost ratios.

Table 3: Profitability of various Natural Farming Systems

Study	Cropping System	Net Return (Rs/ha)	B:C Ratio	Key Findings
Pathania & Spehia (2024) ^[18]	Pea under ZBNF vs CF	-	ZBNF: 2.13 CF: 1.52	32% lower cost of cultivation in ZBNF led to higher B:C ratio.
Choudhary (2021) ^[5]	Wheat - gram intercropping	-	1.84	Max return per rupee with ghanjeevamrit + jeevamrit application
Sharma (2023) ^[25]	Tomato - other vegetables (K) / Cauliflower- other vegetables (R)	K:Rs 2,67,344 R:Rs 1,71,802	-	Cost reduced by 10.37-22.33% (K) & 9.43-18.96% (R) in NF over CF.
Ravishankar <i>et al</i> (2024)	Cassava + vegetable cowpea - greengram	-	-	6% net return gain in NF over ICM due to cost savings
Yadav (2023) ^[31]	Cowpea- fennel	Rs 1,76,623	-	53.43% higher net return over AI-NPOF with complete NF
Laishram <i>et al</i> (2022) ^[15]	Various crop combinations	-	-	Gross return increased by 1.6–6.7% (K) & 0.5–3.2% (R) in NF over CF
Te Pas & Rees (2014) ^[29]	Multiple combinations	-	-	NF consistently gave higher gross returns
Kumar <i>et al</i> (2020) ^[14]	General intercropping	-	-	Intercropping under NF improved farm income

Effect of natural farming on physical and chemical properties of soil

The soil physical and chemical properties of various cropping systems under natural farming are presented in Table 4. Studies reported no significant differences in soil pH and electrical conductivity (EC) between natural and conventional systems (Choudhary *et al* 2021, Darjee *et al* 2024) ^[5, 6]. However, a marginal increase in pH and EC was observed across the years with natural inputs. The pH and EC of soils under conventional farming system ranged from 6.49-7.15 and 0.143-0.255 (dS m⁻¹), respectively, while the soil pH and EC of ZBNF ranged from

6.42-7.56 and 0.142-0.272 (dS m⁻¹), respectively (Pathania and Spehia 2024) ^[18].

Natural farming improved soil organic carbon across various systems. Soil organic carbon increased from 0.90% to 1.04% in soybean + maize–vegetable pea + coriander, and from 0.57% to 0.65% in soybean + maize–wheat + mustard. A slight increase was also noted in cowpea + maize–fennel + cauliflower/cabbage (0.38% to 0.40%) (Ravishankar *et al* 2024) ^[22]. Additionally, organic carbon under ZBNF (19.51 g/kg) was 22.85% higher than in conventional farming (15.88 g/kg) (Pathania and Spehia 2024) ^[18].

Table 4: Soil physical and chemical properties of various cropping systems under natural farming

Cropping systems	Bulk density		pH		EC (dS m ⁻¹)		Soil organic carbon (%)		References
	C	NF	C	NF	C	NF	C	NF	
Cowpea-fennel	-	-	-	-	-	-	0.55	0.60	Yadav (2023) ^[31]
Wheat + gram	-	-	5.24	5.42	0.097	0.112	0.81	1.08	Choudhary <i>et al</i> (2021) ^[5] .
(Soybean + maize) - (vegetable pea + coriander)	1.37	1.31	5.03	5.31	-	-	0.93	0.97	Das <i>et al</i> (2023) ^[7] .
Wheat - mustard	-	-	6.87	6.95	0.19	0.26	0.55	0.68	Janghel <i>et al</i> (2024) ^[12] .
	CF	NF	CF	NF	CF	NF	CF	NF	
Rice - wheat	-	-	8.20	8.37	0.23	0.23	0.42	0.58	Darjee <i>et al</i> (2024) ^[6] .

C: Control, NF: Natural Farming, CF: Conventional Farming

Effect of natural farming on biological properties of soil

Natural farming significantly improves soil microbial abundance and diversity. Application of *Jeevamrit* and *Ghana Jeevamrit* has been reported to elevate populations of nitrogen-fixing bacteria, actinomycetes, fungi, and rhizobia, particularly in intercropping systems such as cotton + greengram and sorghum + chickpea (Saharan *et al* 2023) ^[23]. These microbial communities enhance organic matter decomposition and nutrient

mineralization, thereby improving soil health and productivity. Soil microbial population in various crop/ crop combinations/ cropping systems under natural farming systems are given in Table 5. The congenial microenvironment created by natural farming inputs supports microbial proliferation, in contrast to conventional systems where synthetic agrochemicals suppress beneficial microbial populations (Pathania and Spehia 2024) ^[18].

Table 5: Soil microbial population in various crop/ crop combinations/ cropping systems under natural farming systems

Cropping systems	Bacteria (cfu g ⁻¹ of soil)		Fungi (cfu g ⁻¹ of soil)		Actinomycetes (cfu g ⁻¹ of soil)		References
	C	NF	C	NF	C	NF	
Cowpea - fennel	15.62	29.29	8.43	19.34	13.85	26.06	Yadav (2023) ^[31]
Wheat + gram	16.2 × 10 ⁶	28.7 × 10 ⁶	5.3 × 10 ³	8.7 × 10 ³	14.6 × 10 ⁵	22.8 × 10 ⁵	Choudhary <i>et al</i> (2021) ^[5] .
	CF	NF	CF	NF	CF	NF	
Tomato	103.6 × 10 ⁷	147.9 × 10 ⁷	8.4 × 10 ⁴	15.2 × 10 ⁴	29.0 × 10 ³	48.6 × 10 ³	Yankit 2024 ^[32]
Rice - wheat	15.9 × 10 ⁶	32.5 × 10 ⁶	4.3 × 10 ³	10.4 × 10 ³	11.7 × 10 ⁵	23.6 × 10 ⁵	Darjee <i>et al</i> (2024) ^[6]

The beneficial microorganisms introduced through natural farming inputs play vital roles in enhancing essential soil processes, including phosphate solubilization (Swain and Ray 2007) ^[28], cellulase enzyme production (Bai *et al* 2012) ^[1], overall enzymatic activity (Vijayaraghavan *et al* 2016) ^[30], methane production through methanogenesis (Pradhan and Babu 2012) ^[20], and the release of ammonia (Radha and Rao 2014) ^[21].

Ravisankar *et al* (2024) ^[22] reported significant increases in soil enzyme activities, including dehydrogenase (26.5%), fluorescein diacetate hydrolysis (34.5%), β -glucosidase (14.4%), and alkaline phosphatase (18.8%) under natural farming in a soybean + maize–wheat + chickpea rotation. Soil enzyme activity in various crop/ crop combinations/ cropping systems under natural farming systems is presented in Table 6.

Table 6: Soil enzyme activity in various crop/ crop combinations/ cropping systems under natural farming systems

Cropping systems	Dehydrogenase ($\mu\text{g TPF/g soil/h}$)		Acid phosphatase ($\mu\text{g PNP/g soil/h}$)		Alkaline phosphatase ($\mu\text{g PNP/g soil/h}$)		Urease ($\mu\text{g urea/g soil/h}$)		Fluorescein diacetate ($\mu\text{g fluorescein/g soil/h}$)		References
	C	NF	C	NF	C	NF	C	D	C	NF	
Cowpea - fennel	10.82	19.31	6.32	13.39	8.94	16.54	-	-	-	-	Yadav (2023) ^[31]
Wheat + gram	2.67	5.15	-	-	-	-	-	-	-	-	Choudhary <i>et al</i> (2021) ^[5]
(Soybean + maize) - (vegetable pea + coriander)	28.58	41.81	-	-	-	-	-	-	-	-	Das <i>et al</i> 2024 ^[7]
Soybean + maize -wheat + mustard	64.1	76.7	-	-	-	-	-	-	16.9	22.8	Ravishankar <i>et al</i> 2024
	CF	NF	CF	NF	CF	NF	CF	NF	CF	NF	
Tomato	9.0	22.5	62.8	115.8	-	-	9.2	19.9	9.2	19.9	Yankit (2024) ^[32]

Conclusion

Natural farming offers a promising pathway toward sustainable agriculture by reducing external input dependence, revitalizing soil health, and lowering cultivation costs. This review underscores its varying effects on crop productivity, which depend significantly on the cropping system and agroecological context. While legume- and tuber-based systems show comparable or improved yields under natural farming, intensive cereal-based systems face productivity trade-offs. However, improvements in soil organic carbon, microbial abundance, and enzyme activity highlight natural farming's potential in restoring soil health. Economic analyses further demonstrate better cost-efficiency, particularly for smallholder farming systems. To enhance the viability and scalability of natural farming, further research is needed on long-term soil nutrient balances, pest and weed dynamics and market linkages for natural produce. Policies promoting farmer training, input access, and participatory research will be vital to ensure a successful transition toward ecologically sustainable cropping systems in India.

References

- Bai S, Kumar MR, Kumar DJM, Balashanmugam P, Kumaran MDB, Kalaichelvan PT. Cellulase production by *Bacillus subtilis* isolated from cow dung. *Archives of Applied Science Research*. 2012;4:269-279.
- Barański M, Średnicka-Tober D, Volakakis N, Seal C, Sanderson R, Stewart GB, *et al*. Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. *British Journal of Nutrition*. 2014;112:794-811.
- Bharucha ZP, Mitjans SB, Pretty J. Towards redesign at scale through zero budget natural farming in Andhra Pradesh, India. *International Journal of Agricultural Sustainability*. 2020;18(1):1-20.
- Bhavan K. Technical manual on natural farming. Integrated Nutrient Management Division, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Krishi Bhavan, New Delhi; 2025.
- Choudhary R. Comparative efficacy of different components of natural farming in wheat + gram cropping system [PhD dissertation]. Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Himachal Pradesh, India; 2021.
- Darjee S, Singh R, Dhar S, Pandey R, Dwivedi N, Sahu PK, *et al*. Empirical observation of natural farming inputs on nitrogen uptake, soil health, and crop yield of rice-wheat cropping system in the organically managed Inceptisol of Trans Gangetic plain. *Frontiers in Sustainable Food Systems*. 2024;8:1324798-1324798.
- Das SK, Kumar A, Yadav A, Laha R, Mishra VK. Zero budget natural farming practices on yield of crops (maize + soybean and pea + coriander) in mid hill of Sikkim Himalayas. *Journal of Agriculture and Ecology*. 2023;16:37-42.
- De LC. Natural farming – a sustainable ecological approach. *Research Biotica*. 2022;4(1):5-20.
- Duddigan S, Collins CD, Hussain Z, Osbahr H, Shaw LJ, Sinclair F, *et al*. Impact of zero budget natural farming on crop yields in Andhra Pradesh, SE India. *Sustainability*. 2022;14:1689-1689.
- Duraivadeivel P, Kongkham B, Satya S, Hariprasad P. Untangling microbial diversity and functional properties of Jeevamrutha. *Journal of Cleaner Production*. 2022;369:133218-133218.
- Eliazer Nelson ARL, Ravichandran K, Antony U. The impact of the Green Revolution on indigenous crops of India. *Journal of Ethnic Foods*. 2019;6(1):1-10.
- Janghel GK, Chowdhury T, Singh AK, Soni R, Yadav SK. Changes in physico-chemical and chemical characteristics of soil due to adoption of natural farming practices in wheat-mustard cropping systems. *International Journal of Research in Agronomy*. 2024;7(12):261-269.
- Korav S, Dhaka AK, Chaudhary A, Mamatha YS. Zero budget natural farming: a key to sustainable agriculture: challenges, opportunities and policy intervention. *Indian Journal of Pure and Applied Biosciences*. 2020;8:285-295.
- Kumar R, Kumar S, Yashavanth BS, Meena PC, Ramesh P, Indoria AK, *et al*. Adoption of natural farming and its effect

- on crop yield and farmers' livelihood in India. Hyderabad: ICAR-National Academy of Agricultural Research Management; 2020.
15. Laishram C, Vashishat RK, Sharma S, Rajkumari B, Mishra N, Barwal P, *et al.* Impact of natural farming cropping system on rural households - evidence from Solan district of Himachal Pradesh, India. *Frontiers in Sustainable Food Systems*. 2022;6:878015-878015.
 16. Malakannavar S, Ananthakumar MA, Sanjay MT, Divyashree KS, Nagaraju MC, Bindushree C, *et al.* Comparison of natural farming with organic and conventional farming practices in green gram-paddy cropping system. *Indian Journal of Traditional Knowledge*. 2024;23(8):771-779.
 17. Meena RK, Ram H, Saxena A, Kumar R. Natural farming: basics and application. Karnal, Haryana: ICAR-National Dairy Research Institute; 2024. p. 149.
 18. Pathania N, Spehia R. Potential of natural farming-improves soil health and reduces production cost: study of Solan District, Himachal Pradesh, India. *Vegetable Science*. 2024;51(2):327-334.
 19. Pingali P, Khwaja Y, Meijer M. Commercializing small farms: reducing transaction cost. ESA Working Paper No. 05-08; 2005.
 20. Pradhan P, Gireesh Babu K. Isolation and identification of methanogenic bacteria from cow dung. *International Journal of Current Research*. 2012;4:28-31.
 21. Radha TK, Rao DLN. Plant growth promoting bacteria from cow dung based biodynamic preparations. *Indian Journal of Microbiology*. 2014;54:413-418.
 22. Ravisankar N, Rao VP, Thakur JK, Krishnan R, Rani M, Joshi H, *et al.* Science of natural farming: proven practices and their role in soil health and sustainability. *Journal of the Indian Society of Soil Science*. 2024;72(Special issue):I51-I67.
 23. Saharan BS, Tyagi S, Kumar R, Vijay O, Mandal BS, Duhan JS. Application of Jeevamrit improves soil properties in zero budget natural farming fields. *Agriculture*. 2023;13:196-196.
 24. Sebby K. The Green Revolution of the 1960's and its impact on small farmers in India. Lincoln: University of Nebraska; 2010.
 25. Sharma SK, Ravisankar N, Jain NK, Sarangi SK. Natural farming: current status, research and case studies. *Indian Journal of Agronomy*. 2023;68(22):1-15.
 26. Singh G, Sharma VK, Kaur N, Pathania P, Sharma SK. Productivity and land use of different cropping systems under conventional and natural farming in mid hills of Himachal Pradesh. *Himachal Journal of Agricultural Research*. 2023;78-83.
 27. Smith J, Yeluripati J, Smith P, Nayak DR. Potential yield challenges to scale-up of zero budget natural farming. *Nature Sustainability*. 2020;3(3):247-252.
 28. Swain M, Ray R. Biocontrol and other beneficial activities of *Bacillus subtilis* isolated from cow dung microflora. *Microbiological Research*. 2007;164:121-130.
 29. Te Pas CM, Rees RM. Analysis of differences in productivity, profitability and soil fertility between organic and conventional cropping systems in the tropics and sub-tropics. *Journal of Integrative Agriculture*. 2014;13(10):2299-2310.
 30. Vijayaraghavan P, Arun A, Vincent SGP, Arasu MV, Al-Dhabi NA. Cow dung is a novel feedstock for fibrinolytic enzyme production from newly isolated *Bacillus* sp. IND7 and its application in *in vitro* clot lysis. *Frontiers in Microbiology*. 2016;7:361-361.
 31. Yadav P, Sharma SK, Choudhary R, Jat G, Upadhyay B, Sisodia SS, *et al.* Effect of different natural farming practices on NPK and chlorophyll content of cowpea (*Vigna unguiculata* L.) under sub humid southern plains of Rajasthan. *Biological Forum – An International Journal*. 2023;15(1):289-293.
 32. Yankit P, Chandel RS, Verma S, Sharma PL, Verma SC, Balaso GM, *et al.* Insights on soil biological properties and crop yields under natural farming in western Himalaya. *Indian Journal of Agricultural Sciences*. 2024;94(3-1):89-94.