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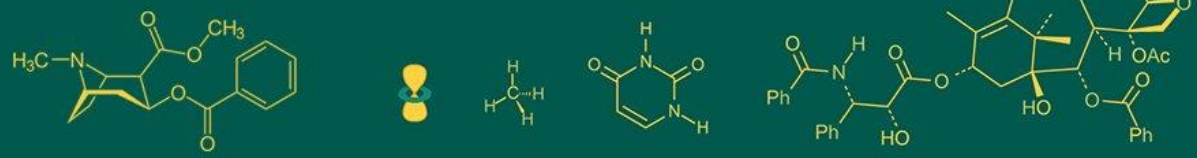

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Natural farming potential to mitigate climate change for sustainable agriculture: A comprehensive review

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Abstract
Natural farming is farming where plants are grown in the natural environment without the use of insecticides, pesticides, herbicides, and any other chemicals. The system works together with each farming region's natural biodiversity to inspire the complexity of living things. In natural farming, instead of using toxic elements, we can use light, alcohol, aroma, and other substances to enhance soil fertility. For chemical substances, we can use other natural sources of nitrogen, phosphorus, and potash. According to Masanobu Fukuoka traditional farming methods in such a way that it requires less labour, with less disruption of nature, and maintain the soil properties. Similarly, Yoshikazu Kawaguchi's practices are based on Fukuoka's principles. His strategies center on minimizing human intervention in the natural world. Korean natural farming by Cho Han Kyu is based on the change of chemical-based and harmful farming methods. According to his natural farming includes indigenous microorganisms, fermented plant juice, and nutritional cycle theory. Zero-budget natural farming is also the other way of farming in which no outside-of-farm inputs are used. Only the inputs available within the farm are used. Effective microorganisms are also used in natural farming this concept is based on introducing a variety of advantageous microbes into the soil, where they improve the conditions for plant growth and health.

Keywords: Natural farming, Sustainable agriculture, rishi krishi, zero budget natural farming, microorganisms

Introduction
In a natural farming system, agricultural practices are done under the laws of nature. This approach supports each farm's natural biodiversity by promoting the growth of complex living things, including the animals and plants that make up each ecosystem. The existence of the soil microbes greatly influences the soil processes, thus enhancing soil health (Bonanomi *et al.*, 2016) [3]. Natural farming is farming related to minimizing the use of external inputs to the farm and nurturing the soil naturally. Zero tillage safeguards soil structure, while mulching efficiently retains soil moisture leading to the conservation of irrigation water. The natural farming system uses the site-specific farm area's natural biodiversity, focusing on the flora and fauna that coexist alongside produced plants. Natural farming differs from conventional farming systems by considering aesthetic and spiritual components in addition to production goals.

Natural farming is a way of perceiving ourselves as a part of nature, not as something distinct from or superior to it. It is also known as "the natural way of farming," "the Fukuoka Method," or "do-nothing farming" (Nene, 2017) [12]. The title relates not to a lack of effort, but to avoiding produced inputs and equipment. Natural farming is like agroecology, agroforestry, eco-agriculture, fertility farming, organic farming, permaculture, and sustainable agriculture, but it differs from biodynamic agriculture.

Before the 1960s, Korean agriculture was regarded as 'permanent agriculture' based on the findings documented in the Korean King's papers during his visits to China, Japan, and Korea in 1909. King found that farmers in these areas had been able to sustain the fertility status of the soil for many years by recycling nutrients in a closed nutrient system that integrated crops and animals at the household level. The average farmed area per household was less than 2 hectares and was centered on subsistence cultivation, with rice serving as the primary staple meal (Perrelet, 2019) [14]. Because no herbicides were employed, rice paddies were still teeming with animals such as frogs and mudfish.

The primary means of weed control was human labour. Farmers in the same village used to form seasonal work cooperatives to oversee group labour since labour-intensive chores like transplanting rice seedlings and harvesting in the late season required a lot of labour.

Natural farming

Masanobu Fukuoka

Masanobu Fukuoka established natural farming. He was a well-known Japanese farmer and philosopher who practiced natural farming and restored decertified land to flora. He supported the no-till, no-herbicide grain-growing farming practices that are customary in many indigenous cultures. He developed a specific farming technique known as "Natural farming" or "Do-nothing farming" based on these practices (Nene, 2017) [12].

The system focused on the recognition and utilization of the intricacy of living species that form an ecosystem. Fukuoka believed that farming was more than just growing food it was also an inventive and spiritual way of living. The cultivation and perfection of human beings was its ultimate purpose. According to Fukuoka, the ground must continue to be covered with weed, alfalfa, white clover, herbaceous legumes, and occasionally intentionally placed herbaceous plants (Korn, 2015) [9]. Grain, vegetable crops, and orchards are present along with ground cover. In orchards, chickens roam freely, while rice fields are overrun with ducks and carp. All the weeds are removed, but they are left on the surface, allowing nutrients to enter the soil while inhibiting weed development.

Fukuoka's Principles

According to Fukuoka, there are five principles in natural farming:

- No fertilizer
- No herbicides or pesticides
- No pruning
- No-tillage
- No weeding

Human soil cultivation is not necessary and ploughing or tilling is also unnecessary, as is the use of powered machines. There is no use of fertilizers as they pollute the environment and are also harmful to human beings. There is no use of herbicides and pesticides. Weeding is not necessary only nominal weed suppression with minimum disturbance to the soil. Pruning of fruit trees is unnecessary (Korn, 2015) [9].

Yoshikazu Kawaguchi

Yoshikazu Kawaguchi is the practitioner of the second generation of natural farmers. His methods are different from those of Fukuoka, yet they are built on the same concepts. Kawaguchi Yoshikazu, a member of the 'second generation' of natural farmers, and the approaches he developed are critical to the spread and promotion of natural farming across South Korea. He was raised on a farm that he inherited in 1955 and practiced conventional farming for over twenty years. Kawaguchi was heavily influenced by Fukuoka's "The One-Straw Revolution" and decided to completely give up the usage of oil-fueled machinery and pesticides in favor of natural farming when his health began to deteriorate due to the agrochemicals he was using in his field (Kato, 2003) [6]. Like Fukuoka's, Kawaguchi's approaches focus on reducing human involvement in the natural environment. The rejuvenation of the field ecology, and nature's intrinsic power, are regarded as the foundation of successful harvests (Perrelet, 2019) [14].

He restates the fundamental principle of organic farming:

- Avoid ploughing the fields.
- Insects and weeds are not competitors.
- No fertilizers need to be added.
- Depending on the local weather and conditions, adjust the food you grow.

Korean Natural Farming (Cho Han Kyu)

In South Korea Natural Farming (NF) was initiated at the Janong Natural Farming Institute by Dr. Cho Han Kyu. Their objective was to change the chemical-based and harmful farming methods that were being practiced in the country. This farming strategy maximizes the use of on-farm resources, recycles the wastes produced on the farm, and reduces external inputs while promoting soil health, and is gaining popularity among Hawaii farmers interested in sustainable agriculture (Keliikuli *et al.*, 2019) [7]. According to him, natural farming includes the following:

- Incubation of indigenous microorganisms.
- Proper planting distance between crops and plants.
- Use of grass mulching as a weed remedy. (Using brown rice vinegar)
- Use of natural and biological agents to avoid pest infestations from the fruits/crops. (Fermented Fruit Juice)
- Use of Nature's Tillers. (Aerobic and anaerobic bacteria, earthworms, fungi, moles, mole crickets, etc.)
- Use of Nutritive Cycle Theory.

Other Forms of Natural Farming

Fertility Farming

The ability of soil to allocate the favourable facilities and nutrients essential for the proper growth of plants is known as Soil fertility. It is the outcome of the physical, chemical, and biological processes that work in a joint to offer essential nutrients, water, aeration, and stability to the plant, as well as freedom from any substances that may restrict the nourishment of plants. In 1951, the "Fertility Farming" method, which is supported by Newman Turner, a system in which there was no tillage, no weeding, no synthetic fertilizers, no composting, no pesticides, and the use of a cover crop (Thakur *et al.*, 2020) [19].

Rishi Krishi

The main aim of Rishi Krishi is to teach the farmer to keep the soil alive indefinitely with the help of cosmic energies, as it is considered the only source of plant growth and development. Plants have their own language to communicate with the living organisms present in the soil. Plants do not require any organic or inorganic fertilizer, including organic waste. Cosmic energy is the only source of plant growth. The use of cosmic energy in its varied forms in its natural way results in bumper crops in the same season (Ram and Pathak, 2016) [15]. The development of Rishi Krishi was based on traditional practices and it was mentioned that the 'Angara' from the rhizosphere soil of the banyan tree (*Ficus benghalensis* L.) and 'Amrit Pani' are the main sources to enhance the biological properties of soil. Amrit Pani is a special bio-enhancer prepared by incubating

cow dung along with cow ghee and honey (Garg and Ram, 2017) [5].

Zero Budget Natural Farming (ZBNF)

ZBNF was pioneered by Sh. Subhash Palekar is regarded as the "Father of Zero Budget Natural Farming" all over the country. Zero Budget Natural farming is a method of farming that emphasizes on the natural development of crops without any addition of fertilizer, pesticides, or any other foreign elements. The word 'Zero Budget' in agriculture, indicates to the zero-net cost of production of all crops (Korav *et al.*, 2020) [8]. A farmer practicing Zero Budget Natural Farming has a lower cost of input and thus has a better capacity to increase income. The crops cultivated under ZBNF help in retaining soil fertility. Cow dung and cow urine are considered the best inputs for seed treatments and other inoculations.

ZBNF has four pillars Jivamrita, Bijamrita, Acchadana (Mulching), and Whapasa (moisture). Other key concepts include intercropping, contour and bund systems, and native earthworm species. Additionally, Palekar provides formulas for pest management, Agniastra, Brahmastra, and Neemastra (Bishnoi and Bhati, 2017) [2]. The system of ZBNF is greatly suited to the farmer particularly small and marginal farmers due to its adaptability, simplicity, and drastic reduction in the overall cost of production.

Organic mulching

Mulching is a farming technique that involves covering bare soil with leaves, straw leaves, and litter. This method prevents the washing away of topsoil, enhances soil fertility and water-holding capacity provides good habitat for microorganisms, promotes humus formation, suppresses weeds, and prevents soil erosion. Mulching also allows the multiplication of microorganisms and earthworms that are required to improve soil quality (Ranjan *et al.*, 2017) [16].

Future perspective and challenges in natural farming

- Natural farming focuses on interacting with ecological processes which is frequently characterized by little external inputs, and faces several challenges. One key obstacle is the potential for lower yields compared to conventional farming methods, as natural farming relies on biological processes that may be more susceptible to environmental fluctuations. Managing pests and diseases without the use of synthetic chemicals poses another challenge, requiring innovative and sustainable solutions. Furthermore, switching from conventional to natural farming methods may be expensive and necessitate a shift in mindset among farmers. Here are some key challenges in natural farming:
- **Yield Variability:** Yield variability in natural farming is a significant challenge arising from the reliance on ecological processes and reduced use of synthetic inputs. Unlike conventional farming methods, natural farming allows for greater influence from environmental factors. Crops are more vulnerable to changes in weather, insect pests, and soil fertility when chemical interventions are not used (Kumar *et al.*, 2020) [10]. This intrinsic diversity can result in unpredictable yields, making it difficult for farmers to provide a constant and reliable output.
- **Weed and Pest Management:** Natural farming emphasizes organic and holistic approaches. This includes the use of companion planting, crop rotation, and biological control methods. However, these techniques may be less potent or require more labour compared to chemical alternatives (Bana *et al.*, 2022) [1]. The absence of synthetic pesticides can result in increased competition from weeds and susceptibility to pest infestations, potentially leading to reduced crop yields. Successful weed and pest management in natural farming demands a thorough understanding of ecological processes, proper surveying, and continuous monitoring to strike a balance between maintaining a healthy ecosystem and achieving optimal crop production (El-Zik and Frisbie, 2018) [4].
- **Knowledge and Education:** Farmers need to acquire knowledge and skills related to natural farming practices. Lack of awareness, training, and education can hinder the widespread adoption of these methods. This includes understanding crop rotations, companion planting, composting, and alternative pest control methods. Additionally, awareness of the long-term outcomes of natural farming in terms of soil health, biodiversity, and environmental sustainability is crucial. Insufficient education and awareness programs may obstruct the widespread adoption of natural farming practices, as farmers may hesitate to change established methods without a clear understanding of the potential benefits (Kunda *et al.*, 2018) [11]. Bridging this knowledge gap through training programs, workshops, and extension services is vital for the successful promotion and adoption of natural farming on a broader scale.
- **Infrastructure and Technology:** Natural farming often relies on traditional and manual methods, which may be labour-intensive. The lack of modern infrastructure and technology can hinder efficiency and scalability. Access to tools and equipment suitable for organic practices may be limited, hindering the scalability of natural farming operations (Roy *et al.*, 2024) [17]. Moreover, the absence of advanced monitoring and data-driven technologies can make it challenging for farmers to optimize their practices and make informed decisions.
- **Climatic Variability:** Natural farming relies on ecological processes that can be sensitive to fluctuations in weather patterns, such as irregular rainfall, extreme temperatures, and unpredictable climatic events. These variations can affect the growth and development of crops, leading to yield fluctuations and potential losses. Additionally, climate changes may influence the prevalence of pests and diseases, complicating natural pest management strategies. Farmers practicing natural farming need to develop resilient strategies that can cope with climate-related challenges, emphasizing the importance of holistic approaches and sustainable practices to mitigate the effects of climate variability on crop yields and overall farm productivity (Singh and Reddy, 2013) [18].
- **Consumer Awareness:** Some consumers may not fully understand the benefits of natural farming, and there could be skepticism about its effectiveness. Building awareness and changing consumer perceptions can be a long-term challenge. Educating consumers about the positive environmental impacts, health benefits, and sustainable aspects of natural farming is crucial for fostering trust and encouraging greater demand for

organic produce. Addressing these challenges requires a collaborative effort from farmers, consumers, policymakers, and researchers, to encourage sustainable agricultural methods and create a supportive environment for natural farming (Nuttavuthisit and Thøgersen, 2017) [13]. A balance between traditional knowledge and modern techniques, as well as support from policymakers and the agricultural community, is essential to overcome these challenges in natural farming.

Conclusion

Natural farming is also known as "do–nothing farming." Natural farming is not just limited to the cultivation of crops, but to conserve the biodiversity in which they are grown and the perfection of the practices conducted by human beings. Sustainable agriculture, organic farming, and fertility farming are all related to natural farming. No equipment, machines, or herbicides are used, and less weeding is beneficial in natural farming techniques. Fukuoka re-invented and developed the usage of clay seed balls, that are employed on desertified areas for re-vegetation. Straw maintains the structure of the soil and nourishes the land, making prepared fertilizer unnecessary. Various farming methods are used to improve soil structure and yield. We can use indigenous microorganisms, fermented plant juice, and the nutritive cycle theory in that natural farming method. These elements contribute to enriching the earth and soil fertility. Natural farming is practiced so that it involves less labour, causes little disruption to nature, and preserves soil properties. Fukuoka does not plough the soil and use ready-made compost, but the soil in his orchards and fields improves year after year. This method produces no pollution and does not require the use of fossil fuels. Excessive use of fertilizers such as urea, nitrate, and phosphorous, as well as many other pesticides, has harmed air, water, and soil quality. So, it was concluded that natural farming is an ideal solution to reducing many hazards.

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