

Zero Budget Natural Farming (ZBNF): A Comprehensive Review of Sustainable Crop Production, Soil Health, and Environmental Conservation

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DOI: <https://doi.org/10.51583/IJLTEMAS.2026.150600182>

Received: 02 July 2026; Accepted: 07 July 2026; Published: 20 July 2026

ABSTRACT

Zero Budget Natural Farming (ZBNF) is an eco-friendly and sustainable agriculture technique formulated as an alternative approach to the current conventional agriculture practices that make intensive use of chemicals. ZBNF was introduced by Indian Agriculturist Subhash Palekar. ZBNF is an agricultural technique that seeks to minimize cost of cultivation, restore soil health, preserve biodiversity, and increase farmers' income through the discontinuation of dependence on artificial fertilizers and pesticides. The process makes use of natural biological processes, indigenous knowledge systems, cow-based bio-formulations, mulching, biodiversity and water conservation. Over the past few decades, there has been an excessive use of chemicals in agriculture leading to serious environmental degradation, decreased soil fertility, pollution of ground water, high costs of cultivation and increased farmer indebtedness. ZBNF was formulated in order to address these issues and has received wide acclaim as an innovative technique for sustainable agriculture, especially in India. The present article gives a comprehensive account of ZBNF in terms of its history, philosophy, science, practice, socioeconomic importance, ecological importance, problems, policies, and future prospects.

Keywords: Zero Budget Natural Farming, Sustainable crop production, Soil health, Environmental conservation

INTRODUCTION

Agriculture forms the basis of our civilization and continues to be the main source of sustenance for a sizable part of the world's population. For the developing nations of the world such as India, agriculture serves the purpose not only of food security but also generates employment and economic stability. The Green Revolution, which took place in the mid-20th century, changed agriculture by:

- High-yielding varieties (HYVs)
- Chemical fertilizers
- Synthetic pesticides
- Mechanization

- Irrigation technologies

The Green Revolution significantly increased food grain production and helped many countries avoid famine. However, over time, intensive chemical-based agriculture created several ecological, economic, and social problems.

Problems Associated with Chemical Farming

a) Soil degradation

Chemical fertilizers decrease soil organic matter content and kill beneficial microorganisms, resulting in loss of soil fertility (Pingali,2012).

b) Water pollution

Runoff and leaching of excess fertilizers and pesticides results in their contamination of rivers, lakes, and groundwater (FAO,2018).

c) Biodiversity depletion

Monocultures and pesticides diminish the populations of helpful insects, birds, pollinators, and soil microorganisms.

d) Debt burden for farmers

The high expenses associated with purchasing seeds, fertilizers, pesticides, and mechanization result in indebtedness of the farmers in case of crop failures (Arora/ICRIER,2024).

e) Harm to human health

Chemical residues in crops and water can negatively affect people's health, potentially causing various diseases, including cancers, neurodegenerative disorders, and hormone disturbances.

f) Global warming

Energy consumption related to manufacture of fertilizers, intercountry transportation of agricultural products, and inadequate planning of time management, production, transportation, and soil management of chemical agriculture is one of its aspects that contribute to global warming (FAO,2018).

Emergence of Zero Budget Natural Farming

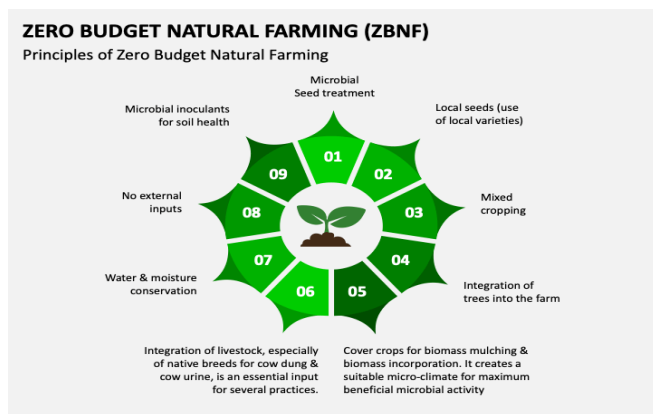
Zero Budget Natural Farming emerged in India during the 1990s as a grassroots farming movement.

Founder of ZBNF

It was conceived by Subhash Palekar, who was at first a practitioner of modern agriculture. He noticed the following trends over a period of time:

- There was a decrease in soil fertility
- Increasing attacks from pests
- Increasing dependence on inputs
- Increasing costs in farming

Palekar researched natural systems, like the forest, and realized that there is plenty of plant life in the forest without any use of fertilizers and pesticides. This made him understand that natural biological processes are enough for plant life.



Meaning and Definition of ZBNF

Meaning of “Zero Budget”

By saying “Zero Budget,” what is implied is that the cost of cultivation must be zero or at least very close to it. The farmers cannot rely on:

- Borrowing from banks
- Chemical costs
- Cost of fertilizers
- Cost of commercial pesticides

The farmers will make use of:

- Local resources
- Waste on the farm
- Local seeds
- Cow-related products

Meaning of “Natural Farming”

Natural agriculture is an agricultural system that conforms to the ways of nature instead of trying to subdue nature.

Key components of natural farming include:

- Soil life activities
- Nutrient cycling
- Diversity
- Ecological balance
- Minimal intervention

Ecological Principles Underlying Zero Budget Natural Farming

ZBNF farming systems are ecological based and are rooted in the ancient agricultural knowledge of India. ZBNF places great emphasis on working with nature rather than relying on any outside chemical inputs. ZBNF is rooted in the knowledge that natural ecosystems like forests support themselves without the use of artificial fertilizers and pesticides due to their continuous nutrient cycling from the breakdown of plant and animal organic matter (FAO, 2018). One of the basic principles of Zero Budget Natural Farming is the belief that soil is not just a growing medium but is actually alive. A healthy soil contains billions of living organisms such as bacteria, fungi, protozoa, algae, actinomycetes, and earthworms, which help in decomposition of organic matter, cycling of nutrients, building of soil structure, and plant growth. It becomes imperative to preserve the biodiversity of the soil organisms so that the soil fertility can be maintained and crops can continue to yield. Various farming systems are able to foster beneficial microorganisms, pollinators, predators, and other creatures that can help in controlling pest infestations and diseases, thus contributing to greater stability within ecosystems. Monoculture agriculture, on the other hand, tends to destabilize the ecological balance, leading to vulnerability of crops to disease outbreak, pest infestation, and climate change factors. Besides, ZBNF makes use of various indigenous ecological knowledge systems developed over the course of centuries as a result of observation and experience of local farmers. Through the combination of such indigenous knowledge with scientifically proved sustainable practices, ZBNF tries to create viable agricultural systems.

Core Components of ZBNF

The foundation of ZBNF rests on four major principles:

1. Jeevamrutha
2. Beejamrutha
3. Mulching
4. Waaphasa

Jeevamrutha: Preparation, Scientific Basis, and Functions

The Jeevamrutha is a fermented liquid-based bio-inoculant which is considered to be the “heart” of ZBNF due to its importance in promoting biological activity and fertility of the soil. This substance is produced from readily available materials such as 10 kg of local cow dung, 10 litres of cow urine, 2 kg of jaggery, 2 kg of pulses flour (for instance, gram flour), handful of healthy local soil, and 200 litres of water. These materials are mixed together in a large vessel; then, the mixture is alternately stirred in clockwise and anti-clockwise directions, and then left to ferment for 48 hours. Jeevamrutha is based on science due to the presence of abundant numbers of friendly microorganisms in Jeevamrutha, such as bacteria, fungi, actinomycetes, and nutrient solubilizers (Rathore et al., 2024). The presence of such microorganisms leads to faster decomposition of organic matter, conversion of non-available nutrients to available nutrients, soil aggregation, humus formation, and thus better biological health of soil. Use of Jeevamrutha regularly causes increased microbial action leading to increased availability of nutrients, better soil structure, higher porosity, and better water retention capacity. Jeevamrutha leads to vigorous growth of roots through interactions between beneficial microorganisms and creates conducive conditions for earthworms that increase soil aeration and productivity.

Beejamrutha: Preparation, Importance, and Benefits

Beejamrutha is a natural seed treatment solution that is commonly used in ZBNF for protecting seeds against various diseases as well as establishing healthy plants. Beejamrutha is made from cow dung, cow urine, lime, fertile soil of the locality, and water; these materials constitute a good source of various microorganisms. The seeds are then covered with the solution made from these materials and left to dry under shade so that the good microorganisms can settle on them. The main purpose of Beejamrutha is to protect the seeds from various fungal

diseases, soil-borne diseases, and seed rots. Beneficial microorganisms help in suppressing the harmful microorganisms in order to lower down their occurrence and thus keep the seeds healthy. Hence, through the use of Beejamrutha, one can be assured of better germination and better growth of seeds into the plants, with stronger roots system.

Mulching: Types, Importance, and Benefits

Mulching is an essential activity in Zero Budget Natural Farming (ZBNF), and it is carried out through placing organic matter on the soil to reduce moisture loss, improve soil quality, and create appropriate conditions for the growth of the crops. In line with the nature of the farming system adopted, there are different ways of carrying out mulching activities, such as soil mulch whereby soil tilling is minimized in order to maintain soil moisture and its structure, straw mulch which entails using crop residues, dry leaves, or other plant matter as the mulch for the soil, and live mulch which involves growing cover crops alongside other crops. Mulching activities offer various advantages. Moreover, the covering layer helps regulate the soil temperature to protect the plant roots from excess heat and provides ideal conditions for microbial activities. Besides, mulching helps avoid soil erosion through wind and water, ensures retention of the fertile topsoil, and increases the soil organic matter as the mulch decomposes. The decomposition process improves the soil nutrient content, soil structure, and soil biota. Lastly, mulching limits the growth of weeds by preventing light penetration into the soil. Thus, mulching is a sustainable approach to soil management.

Waaphasa: Concept, Scientific Importance, and Benefits

The Waaphasa concept of Zero Budget Natural Farming (ZBNF) is an essential principle of ZBNF that pertains to the soil state where there is an optimal combination of air and water vapor, not too much of water in the pores of soil. The main idea of this principle is to provide sufficient aeration of soil instead of regular irrigation, since healthy roots of plants need oxygen to respire and take up nutrients. Over irrigation leads to the shortage of oxygen in the area near the roots, provokes root diseases, causes the process of nutrient leaching and has negative effect on plants. Sufficient aeration of soil provides suitable conditions for root formation, activity of useful microorganisms, as well as rational usage of water. Consequently, crops need fewer irrigations which allows saving water. In addition, better-aerated soils make plants have healthier roots which are able to absorb water and nutrients in a more effective manner. Also, reduced irrigation means lower usage of electricity or fuel needed to pump water which results in the reduction of production expenses.

Natural Pest and Disease Management

Pest and disease control are an essential aspect of ZBNF, which avoids the use of chemical pesticides but rather utilizes botanical and cow-based extracts for the purpose of managing pests in a way that is environment-friendly. Pest suppression using these natural extracts helps reduce pesticide residues, while still keeping a balance of the ecosystem by protecting beneficial organisms. Some of the commonest preparations include Neemastra, which is a combination of neem leaves, local cow urine, and cow dung. The extract works against sucking pests like aphids and whiteflies, as well as chewing insects like caterpillars. The effectiveness of its insecticidal nature is attributed to the presence of azadirachtin, which is a bioactive substance found in the plant and functions as an insect repellent, feeding deterrent, and growth regulator (IJPSS). Agniastra, which is extracted from the ingredients such as chili, garlic, tobacco, and cow urine, is an efficient botanical preparation which can be used to get rid of severe pest infestation because of its effective insect-repellant and insecticide properties (Kumar et al., 2024). The other significant preparation called Brahmastra is extracted from the leaves of pesticidal and medicinal plants like neem, custard apple, papaya, and guava. This preparation acts as an all-purpose pesticide with less harm to the environment (Rathore et al., 2024).

Cropping Systems in ZBNF

Diversified cropping is one of the key elements of sustainable agriculture that boosts productivity, resilience, and effective use of resources. Such approaches like inter-cropping, mixed cropping, crop rotation, and agroforestry are associated with the improvement in soil quality, biodiversity, and economic viability.

Intercropping, namely the growing of corn and pulses together, facilitates effective use of nutrients, increases biological nitrogen fixation, improves biodiversity and helps farmers to diversify income streams. Mixed cropping means planting different types of crops at the same time in the same field in order to minimize risks of crop failure because of pests, diseases or poor weather. In crop rotation different crops are planted on the same field on an annual basis and it helps to maintain soil fertility, improve nutrients balance, prevent the recurrence of pests and diseases and decrease the use of chemical inputs. Agroforestry includes tree plantations and crops planting and provides shade, biomass, and organic material, helps to sequester carbon, preserve biodiversity and earn additional money from timber, fruits, fodder or fuelwood.

Scientific Principles Underlying ZBNF

Soil microorganisms play an important role in sustaining soil fertility and sustainability of ecosystems. These include helpful bacteria, fungi, among others which enable biological nitrogen fixation, phosphorus solubilization, and the decomposition of organic matter, thus increasing availability of nutrients to plants. Nevertheless, excess and prolonged usage of chemical fertilizers may negatively impact soil biodiversity and biological activity, thus interfering with the above processes. In natural ecosystems, there is constant recycling of nutrients from the decomposition of plant and animal materials, guaranteeing a sustainable supply of nutrients with reduced loss of nutrients. Biodiversity increases the sustainability of agriculture by providing habitats for natural predator and helpful organisms, hence reducing reliance on chemical pesticides. In addition, organic agriculture that involves the application of compost, farm yard manure, crop residues, cover crops, among others contributes towards the improvement of soil organic carbon and atmospheric carbon dioxide (CO₂) sequestration.

Economic Importance of ZBNF

Sustainable agriculture is able to bring down the cost of production to a great extent through the low use of costly inputs such as chemical fertilizers, pesticides, and hybrid seeds. The use of local resources, organic manure, and saved seeds brings down the cost of production to a considerable level. With the reduction in the cost of production, there is less dependence on credit and loans, and hence lesser financial risks. Yields might not be very high, but still the low cost of production often leads to increased profits for the farmers.

Environmental Benefits

Sustainable agriculture is important for the conservation of the environment because it helps in the revitalization of the soil as well as improving its ecological function. Organic matter adds to soil quality in terms of improving its structure, increasing its water retention ability and fostering beneficial microorganisms. Mulching and Waaphasa (a process that involves ensuring that there is a perfect balance between the air and moisture levels in the soil) ensure less use of water while maximizing the use efficiency of water used. Natural farming systems encourage the existence of diversity in the environment by creating favourable conditions for pollinators, earthworms, birds, and beneficial insects, which are responsible for pollination and natural pest control.

Social Significance

The practice of natural farming is a liberating factor for the farmer, in the sense that it minimizes dependency on chemical fertilizer industries and expensive inputs, thus promoting self-sufficiency among farmers. As natural farming methods like making bio-inputs, mulching, and mixed cropping demand manual labor, they provide employment avenues for the rural community as well. Natural farming practices contribute to the conservation and revival of traditional agricultural knowledge systems by adopting traditional farming practices and resource management strategies.

ZBNF and Climate Change

Climate change is a major problem for agriculture as far as increasing frequency of droughts, floods, heat stress, and other forms of severe weather pose threats to the productivity of the crops and to the security of food supplies. The practice of natural farming, and in particular Zero Budget Natural Farming (ZBNF), makes agriculture systems more resilient as it improves the moisture content in the soil due to higher organic matter content and

mulching. It also contributes to carbon sequestration as one of the means of lowering greenhouse gas emissions and preserving biodiversity that ensures stability of ecosystems and natural pest regulation.

Challenges and Criticism

Natural farming methods, though environmentally and economically sustainable, come with a number of challenges that might affect its widespread adoption. The adoption of natural farming from conventional methods will likely lead to a decrease in crop productivity during the period when soil biological activity is revived. Moreover, there are concerns among researchers regarding the sustainability of the yield, nutrient adequacy, and widespread applicability of the natural farming systems, requiring additional scientific validation (Arora/ICRIER, 2024). Preparation and use of natural inputs like bio-formulations involve extensive work, time, and expertise. Another challenge in the adoption of natural farming methods is the use of cow-based inputs since indigenous cows are essential for the process. Marketing is another important obstacle because of the lack of market and certification for naturally farmed products and premiums for them.

Government Support and Policies

Several efforts have been undertaken by the Government of India towards natural farming. Some of these schemes are the Bharatiya Prakritik Krishi Paddhati (BPKP), Paramparagat Krishi Vikas Yojana (PKVY) and the Andhra Pradesh Community Managed Natural Farming (APCNF) programme. These efforts give farmers training and financial support, as well as demonstrate the effectiveness of natural farming practices and create awareness for the same. These government schemes contribute to making Indian agriculture sustainable by making the process of agriculture more friendly to the environment, thus improving the health of soil and livelihoods of the farmers.

Comparison Between Conventional Farming and ZBNF

Parameter	Conventional Farming	ZBNF
Fertility Source	Chemicals	Natural microbes
Pest Control	Synthetic pesticides	Botanical extracts
Cost of Cultivation	High	Very low
Soil Health	Often degraded	Improved
Water Use	High	Lower
Biodiversity	Low	High
Environmental Impact	Polluting	Eco-friendly

Future Prospects

The future success and widespread adaptation of Zero Budget Natural Farming (ZBNF) require a proper balance between science, policies, and stakeholder involvement. Proper validation via robust field trials is necessary to assess the impact of Zero Budget Natural Farming on crop production, soil conditions, nutrient cycling, and climate change adaptation. Capacity building among farmers is also necessary for increasing their knowledge and implementing ZBNF practices effectively. Apart from that, policies and investments in research and innovation as well as the development of market linkages for naturally grown crops may contribute to the popularity of ZBNF because it would ensure higher profitability. Consumer awareness of the advantages of ZBNF in terms of environment protection and human health could be another factor motivating farmers to switch to this farming system. The combination of innovations from modern science and indigenous ecological knowledge could be an efficient way to design resilient and productive agroecosystems.

CONCLUSION

Zero Budget Natural Farming represents a holistic approach to sustainable agriculture that seeks to restore ecological balance, reduce cultivation costs, and improve farmers' livelihoods. By emphasizing natural biological processes, biodiversity, and local resource utilization, ZBNF offers a viable alternative to chemical-intensive farming systems. Although several challenges remain, including scientific validation, scalability, and transition difficulties, the environmental, economic, and social benefits of ZBNF make it an important strategy for achieving sustainable agriculture and climate resilience in the future. As global concerns regarding food security, environmental degradation, and climate change continue to grow, farming systems such as ZBNF may play a crucial role in creating a healthier and more sustainable agricultural future.

ACKNOWLEDGEMENTS

I would like to extend my heartfelt thanks to the School of Agriculture Sciences, K.K. University, Nalanda, Bihar, for providing me with the best academic surroundings and facilities along with support in conducting this research. The help provided by them was immensely useful in accomplishing this research.

Author's contribution

Sakshi and NK collected the review of literature, conceptualized and prepared the manuscript as part of research work under the supervision of SRM and BKP. SRM guided the overall structure, provided critical reviews and supervised the review process.

Compliance with ethical standards

Conflict of Interest: The authors assure and clarify that there are no known conflicts of interest occurs which could influence the research pointed in this review. This work has been presented and conducted independently without financial or personal relationships that could be perceived as biasing the content.

Ethical issues: None

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