Effects of zero-budget natural farming on yield, earthworm populations, microbiological activity, and the requirement for public Policy: A Review

Abstract

At this moment, Indian agriculture is facing a crucial crisis due to the diminishing hope of the green revolution. Overuse and wasteful exploitation of the green revolution's crops have negatively impacted food security and the environment. In recent years, Zero Budget Natural Farming (ZBNF), a rapidly expanding farming method influenced by agroecological principles, has been suggested to increase farm viability and food security. By 2050, sixty percent of Indians will have severe food insufficiencies. There is an urgent need for increased food production, yet farmers are becoming indebted due to the high cost of production and shifting market pricing. ZBNF (zero-budget natural farming) is the best option for dropping farmers' input costs. This paper reviews the concepts of natural farming in the context of its eco-friendly nature and sustainability.

Keywords: Conventional agriculture, Environmental safety, food security, green revolution, Indian agriculture, zero-budget natural farming

Introduction

India has the second-largest amount of agricultural production in the world, supported by its arable land area (about 159 Mha). This sector is one of India's most significant ones because it generates more than 15% of the national gross domestic product **(Yadav et al, 2021).** Feeding a projected population of 9 billion people who will exist by the mid-century constitutes one of the most fundamental challenges facing humanity **(Watson et al, 2019).** This was initially facilitated, in part, by Green Revolution technologies to increase yields and profits, compared to traditional techniques**.** Conventional agriculture relies largely on the input of pesticides, fertiliser, and energy from fuel. When humankind is benefiting greatly from the wealth brought about by economic growth and technical advancements, severe environmental and food safety concerns have vanished from view. Excessive use of chemical fertilizers and pesticides have caused environmental pollution and degradation, impaired food safety and quality and adverse effect on human and animal health **(Bhattacharyya et al, 2015; Connor and Mínguez, 2012)**. Because of the overuse of chemical fertilisers and pesticides in agricultural production, people are concerned about the potential negative impacts on the environment, including polluted air, water, and food. The rapid deterioration of both the natural environment and agricultural products has become a matter of great concern for many people in the world. The concept of Zero Budget Natural Farming (ZBNF) was first popularised by agriculturist Sh. Subhash Palekar in the middle of the 1990s. In 2016, he was given India's highest civilian honour, the Padma Shri, for his work promoting this alternative farming method **(Khadse et al, 2018)**. In order to increase farmers' income, the Economic Survey (2019) highlighted the importance of Zero Budget Natural Farming

(ZBNF) as a potential alternative farming practice. In addition to substituting chemical fertilizers with home-grown products such as Jeevamritha, Beejamritha and Neemastra, and applying intercropping and mulching, these practices are considered to drastically reduce cost of production **(Biswas 2020).**

ZBNF is a grassroots agrarian movement that uses inexpensive, homegrown fertilisers that are sourced locally. By avoiding the use of agrochemicals and agribusiness, ZBNF achieves food security for the world and environmental preservation **(Duddigan et al, 2022)**. APCNF or Andhra Pradesh Community-Managed Natural Farming has been widely adopted in Andhra Pradesh (southeast India). By partnering with the not-for-profit organization Rythu Sadhikara Samstha, **(RySS)** the Andhra Pradesh Department of Agriculture is promoting ZBNF adoption. In 2020, 580,000 farmers will use ZBNF techniques **(Duddigan et al, 2022)**, and the local government extend the program to 6 million farmers **(Tripathi et al, 2018).** According to estimates, Andhra Pradesh could save USD 70 million annually on fertiliser subsidies if ZBNF covered 25% of the state's total cropland **(Gupta et al, 2020).** Similar techniques used by ZBNF and conservation agriculture to lessen soil disturbance include using crop remnants, intercropping, and minimizing tillage **(Ravisankar et al, 2020).** However, ZBNF stands out since it combines these methods with particular handmade alterations. The subsequent focus on developing sustainable and equitable approaches to agriculture underpins the Zero Budget Natural Farming (ZBNF) approach, which aims to address both environmental and socioeconomic concerns within the agricultural sector.

ZERO BUDGET NATURAL FARMING (ZBNF)

As the name speaks, ZBNF is a natural way of farming without any capital investment. The term "Zero Budget" refers to reducing the amount of purchased inputs and agribusiness involvement while also lowering farmer debt **(Smith et al, 2020)**. 'Natural Farming' refers to the use of homemade amendments from readily available ingredients. By using these inputs and integrating pest management and intercropping, soil health will be promoted, nutrient cycling loops will be closed, and water will be retained in the soil for a longer period **(Bhatt et al, 2019; Keerthi et al, 2018)**. In essence, it returns to the sole utilization of abundant natural resources, which ancient agriculture completely depended on. Presently, when production costs are rising sharply and production rates are stagnating, along with environmental footprints associated with chemical pesticides and fertilizers, ZBNF is gaining traction as it improves soil health through diversity, microbial activities, nutrient recycling, and beneficial biological interactions, leading to sustainable crop production **(Moss and Bittman, 2018)**. It is a particularly extreme instance of low-input sustainable agriculture (LEISA), in which all inputs are readily available locally (on the farm), and the output of one farming system is mostly used as an input in another farming system. Rather, an extreme form that doesn't hesitate to assert that no external inputs are required. All inputs must be gathered locally and symbiotically from the hamlet and its surrounding areas (or even from within the farm). This is a dynamic system wherein outputs are likely to be input to at least one of the other outputs. More importantly, as none of the inputs are sourced from outside the system then there is no cost, and it is this that is referred to as zero budget natural farming (ZBNF).

According to Sh. Subhash Palekar, the ZBNF/NF has following 4 essential components:

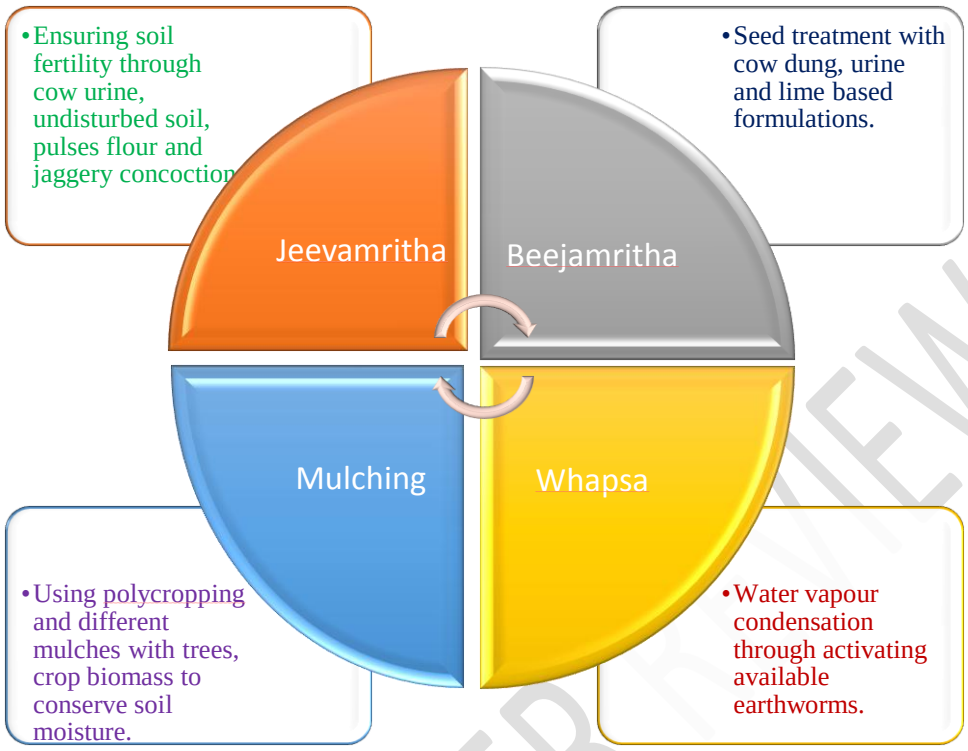

Fig 1: Four essential components of zero budget natural farming.

1) **Jeevamritha:** Jeevamritha is a fermented microbial culture. In addition to providing nutrients, it also serves as a catalytic agent that encourages the activity of soil microorganisms and boosts the population of native earthworms.

• **Preparation of Jeevamritha:** Put 200 litres of water in a barrel, Add 10 Kg fresh local cow dung, 5 to 10 liters of aged cow urine, 2 Kg of Jaggery (a local type of brown sugar), 2 Kg of pulses flour and a handful of soil from the bund of the farm. Stir the solution well and let it ferment for 48 hours in the shade. Jeevamritha is ready for application. It is sufficient to cover one acre of land with 200 litres of Jeevamritha. The aerobic and anaerobic bacteria found in cow dung and urine increase while consuming organic materials (such as pulse flour and jaggery) during the course of the 48-hour fermentation process. A handful of undisturbed soil acts as inoculating of native species of microbes and organisms. Jeevamritha also helps to prevent fungal and bacterial plant diseases.

• **Application of Jeevamritha:** It should be sprayed on the crops twice a month with a 10% foliar spray or irrigation water. The preparation is stored up to a maximum of 15 days. For horticultural crops, Jeevamritha is applied to the individual plant. In Maharashtra, the majority of the sample farmers are applying Jeevamritha through drip irrigation method. The application of Jeevamruth increased crop output and promoted the development of beneficial soil microbes **(Shaikh and Gachande, 2015)**.

2) **Beejamritha:** Beejamritha is a treatment used for seeds, seedlings or any planting material. Beejamritha is effective in protecting young roots from fungus as well as from soilborne pathogens and seed-borne diseases that commonly affect plants after the monsoon period. It is also helpful in producing IAA and GA **(Sreenivasa et al, 2010).**

   • **Preparation of Beejamritha**- Mix local cow dung, considered to be a natural fungicide, and cow urine (an anti-bacterial liquid), lime and soil. After being tied in a cloth, the dung is kept in urine for about 12 hours. Cow dung is squeezed out of cow urine, and then 50 grams of lime are added to the urine.

   • **Application/seed treatment:** Mix Beejamritha with seeds of any crop, coat them, and dry them thoroughly before sowing. Leguminous seeds can be dipped quickly and dried.

3) **Acchadana – Mulching:** Three types of mulching have been suggested under ZBNF:

   Soil Mulch: This prevents tilling from destroying topsoil during farming. It promotes aeration and water retention in the soil. Because of this, it's best to avoid deep ploughing.
   Straw Mulch: Dried biomass waste from earlier crops is typically referred to as straw material. As organic materials decompose and become humus, they are activated by the soil biota and microbial cultures.
   Live Mulch: To provide all necessary nutrients to the soil and crops, it is crucial to establish multiple cropping patterns for monocotyledons and dicotyledons cultivated in the same area. Dicot groups such as pulses are nitrogen-fixing plants. Monocots such as rice and wheat supply other elements like potash, phosphate and sulphur.

4) **Whapasa- moisture:** The advocates of ZBNF counter the over-reliance on irrigation in green revolution farming. Whapasa occurs when the soil contains both air and water molecules. As a result, only irrigating at noon, in alternate furrows, may fulfill the moisture requirement of the crops, a significant decline in need for irrigation in ZBNF. However, rarely this practice is followed by any farmer.

In an interactive workshop discussion with stakeholders, it was suggested that the four wheels of ZBNF could increase yields through a variety of biochemical interactions (Figure 2). The ZBNF system is believed to dramatically increase soil biodiversity as a result of the amendments provided, and as a result, this diversified belowground biological population offers many ecosystem services, such as nutrient delivery, carbon storage, and resistance to external pressures. To support the alleged mechanisms involved in crop output maintenance in the ZBNF system, additional research is required. However, there is a body of research into the benefits of systems that use seed treatments of Ferula spp. (e.g., ‘asafoetida’) **(Kavoosi et al, 2013: Sitara and Hasan, 2011)** and P. emblica **(Mohana et al, 2011)** inoculum and biostimulants **(Colla and Rouphael, 2015; Trabelsi and Mhamdi, 2013)** and organic matter applications **(Lima et al, 2009)** from which the stakeholders, and we, could draw parallels to ZBNF.

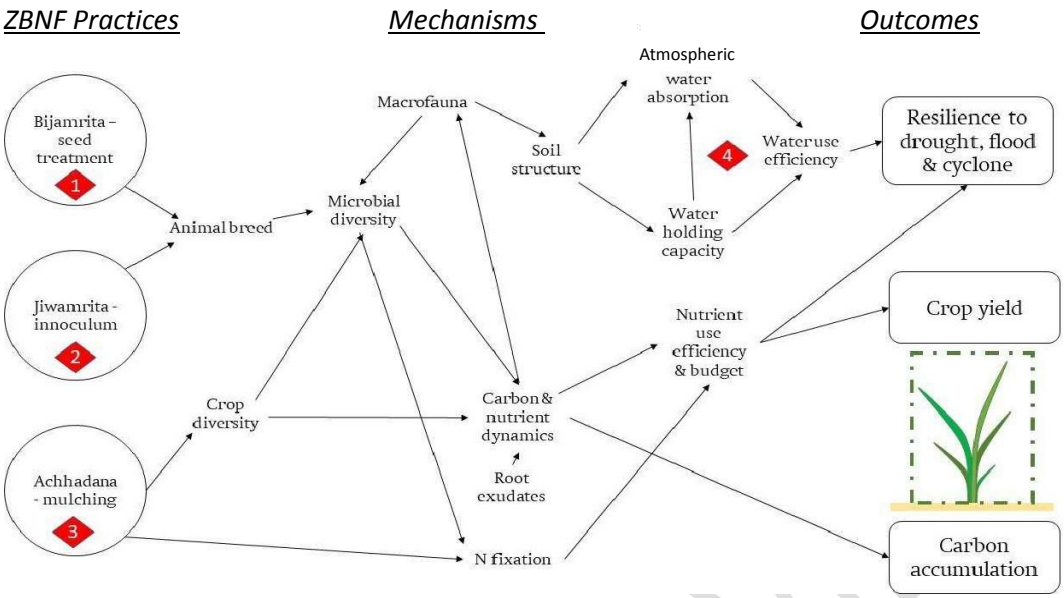

Figure 2. Conceptual model linking operations of ZBNF with biogeochemical processes.

In assessing agricultural sustainability, yield is an important factor to consider **(Corsi et al, 2012)**; By tracking the yield, we can evaluate how well ZBNF contributes to SDG 2 (Zero Hunger). However, we acknowledge that when taking into account ecological services, human and soil health, or the socio-historical subjectivity of ZBNF farmers, yield is not necessarily the most crucial element **(Walker et al, 2021)**, which drives the adoption of farming practice. Our next steps in assessing the efficacy of ZBNF must build on the simple metric of productivity in terms of yield to encompass environmental and socially progressive outcomes **(Wezel et. al. 2020)** in order to reflect contributions to other Sustainable Development Goals.

Pest control solutions

ZBNF-adopting farmers assert that when chemical fertilizers are given to crops, the crop's vegetative development is excellent and luscious green. Because of this, crops are attacked by insects and pests. While in case of Jeevamritha, the leaves colour is not that much green and therefore, the menace of pests is limited. However, the farmers develop various formulations (Kashayam) composed of locally accessible plant materials when an infestation occurs to suppress the pests. Some of these are:

1. **Neemastra:** It is the most important pest-control solution prepared by farmers. The neemastra is prepared with water, neem plants, cow urine, and cow dung. Neem leaves are made into a paste by grinding them, then mixing them in water. Without dilution, the solution is applied directly to plants. The mixture consists of 5 kg of neem paste, 2-3 kg of cow dung, 10-20 liters of urine, and a handful of soil. The mixture ferments for approximately 48 hours. Depending on their needs and crops, farmers produce solutions in volumes ranging from 100 to 200 litres.
2. **Brahmastra**: It is prepared from different types of bitter leaves**.** Neem leaves are mixed with other leaves that have a bitter taste, such as custard apples, chilies, etc. It takes about two to three hours to boil approximately 20-30 litres of cow urine. After

Fungicide/ Insecticide	Ingredients	Quantity used in mixture

the solution has cooled for about 12 hours, it is filtered with fine cloths. For every litre of Brahamastra, the solution is further diluted with around 15 litres of water.

3. **Agniastra**: It is prepared by adding about 5 kg of neem paste to 1 kg of tobacco leaves, 0.5 kg of spices, and 0.5 kg of garlic paste. These are cooled for around 24 hours after being mixed with 25 to 30 litres of cow urine. The solution is filtered with fine cloths and then used. Before using it in the field, the solution is diluted with a half-litre of Agniastra 15 litres of water or so are added. Among the insects that Agniastra is effective against are Leaf Roller, Stem Borer, Fruit Borer and Pod Borer.

4. **Tutikada rasam:** It is prepared from datura leaves and cow urine. The leaves are boiled in cow urine for 2-3 hours and is cooled then it is filtered using cloth.

5. **Dashparini Kashyam:** It is prepared from ten types of plant leaves. The leaves of Neem, Agele marmelos, Calotropis, Senna auriculata, Papaya, Custard apple, Gauva, Vitex negundo, castor, Pomegranate, Nerium, Ocimum, Aloe vera, Tobacco, Datura, Lantana camara and Pongamia pinnata are used in preparing the solution. Green chilli and garlic are also crushed and added and mixed with 20 litres of cow urine. It is kept up to 45 days for fermentation. The solution is filtered and sprayed after dilution. In about 8-10 litres of solution, 100 litres of water is added for dilution.

Table 1. Ingredients and their quantity that are used to make some other biopesticides (Babu 2008)

Fungicide-I	Butter milk fermented for 5 days	5 litres
	Water	50 litres
Fungicide-II	Indian bred cow milk	5 litres
	Black Pepper Powder	200 g
	Water	200 litres
Insecticide-I	Neem seed or leaf powder	20 kg
	Water	200 litres
Insecticide-II	Indian bred cow urine	5 kg
	Indian bred cow dung	10 litres
	Neem leaves	10 kg
	Water	200 litres
Insecticide-III	Neem leaves soaked in cow urine for 10 days	10 kg
	Tobacco powder soaked in cow urine for 10 days	3 kg
	Garlic paste soaked in cow urine for 10 days	3 kg
	Green chilli paste soaked in cow urine for 10 days	4 kg

OTHER PRACTICES OF ZBNF

Intercropping and Crop Rotation: Intercropping is the simultaneous cultivation of two or more distinct crops on the same plot of land. Intercropping aims to improve solar radiation harvesting, land utilization, erosion control, and soil utilization. Additionally, it helps increase farmers' revenue or provide food in the event that their primary crop fails. The component crops of the intercropping system include legumes, millets, grains, vegetables, fruit trees, medicinal plants, etc. It is also important for ZBNF to diversify its cropping system because it breaks up habitats and consequently reduces pest and disease populations.

Bunds and Contours: Bunds and contours are constructed with the intention of minimizing water-borne soil erosion and conserving rainwater for crop production.

Indigenous Earth Worm Species: The incorporation of vermicompost into the soil is not encouraged in ZBNF. As per Palekar, deeper soils can be enriched with organic matter if they are treated with native earthworms, so external vermicompost is not necessary. He said that exotic earthworm species, in particular Eisenia foetida, are hazardous because they contaminate soil and groundwater by absorbing harmful metals **(Mishra, 2018)**

Cow Dung: Indian species have more beneficial microorganisms in their faeces (around 3-5 crores) than foreign breeds, hence only native Indian cows (Bos indicus) faeces are advised in ZBNF activities. Palekar claims that the faeces of foreign breeds contain numerous harmful bacteria, fungi, and other pathogens, while Indian breeds are only found to be effective for crop cultivation. One Local indigenous cattle breed can cultivate 30 acres of land. In order to ensure the success of the ZBNF, promoters suggest that cattle faeces shouldn't be mixed between Indian and foreign breeds of cattle. They advise farmers to use the dung and urine of

local Indian cows for ZBNF, while cows of foreign breeds should be used for biogas or fuel **(Munster, 2017)**. The majority of ZBNF supporters have stopped drinking milk and milk products as they avoid the dairyfication of local cows to let these precious species shower benefits in crop production purposes only.

BENEFITS OF ZBNF

On June 26, 2018, the New York Times ran the headline "Bringing farming back to nature" and pointed out the dire consequences for agriculture if nature is disregarded **(Moss and Bittman, 2018)**. A true example is the green revolution, which is no longer relevant because its artificial techniques did not increase yield and had negative effects on the environment. In context with the food crisis, climate change, natural resource depletion, migration, and farmer suicides, as well as other factors **(Biswas, 2020),** ZBNF is possibly the most successful agrarian movement in the world in terms of its reach **(Khadse et al, 2018).** By shifting modern agriculture to a zero-budget natural farming approach, there are several benefits. ZBNF totally relies on using internal inputs, which reduces the need for borrowing for farming activities. Therefore, it can be a measure to minimize indebtedness and suicide in farming communities (particularly of the small and marginal categories). Further, by removing chemicals (such as pesticides and fertilizers) from farming operations, ZBNF can prevent further deterioration and successfully restore the health of the ecosystem and soil. Additionally, it promotes soil aeration, bunds and topsoil mulching, intercropping, and less water application, all of which, while not immediately increasing productivity, can boost farmers' income by fostering the development of self-sustaining systems after at least three years of the conversion period. In addition, ZBNF can be a good alternative given the current labour shortage (caused by unwillingness to choose farming as a profession and consequent migration to urban regions for other employment), as it does not encourage diverse intercultural operations and as a result, the engagement of hired manual labourers. As there is no peak season in ZBNF models (such as 5 years model **(Murali, 2016),** due to diversified culture, need to hire labour in a particular time (specially, in a labour crisis) can be minimized. As a result, ZBNF may be able to reduce the amount of energy used to produce one unit of gross domestic product **(Tripathi et al, 2018)**. Moreover, ZBNF can reduce material footprint per unit capita and per unit value added in agriculture by reducing external inputs and promoting waste recycling instead of dumping or burning.

Principles of ZBNF:

Some of the other important principles of ZBNF are intercropping where in addition to combining monocot and dicot crops in a single plot of land it also articulates the relevance of crop-tree association (and that will add to income from additional sources), the role of contours and bunds to preserve rainwater and promote maximum efficacy for different crops, the need to revive the local deep soil earthworms and not to rely on vermicompost (in particular, the Eisinea feotida worm, exotic to India should be avoided), and to use the indigenous humped cow (Bos Indicus) for their dung and urine because they have a greater concentration of micro-organisms. Further, depending on the nature and type of insect/pest

attack, zero-budget natural farming has come up with different formulations (neemastra, agniastra, and bramhastra among others) from locally available resources that work as bio-pesticides. Before exploring the application of ZBNF in Karnataka and Andhra Pradesh, we will briefly discuss the links of ZBNF with agroecology and articulate its risk-reducing ability.

Effect on ZBNF on different parameters:

First claim: Effect on yield

The first claim put forward by ZBNF promoters is that the use of ZBNF practices mostly crops enhance the yield compared to 'non-ZBNF'. Adaptation of ZBNF yield increased by up to 22 percent for crops such as gram, lentil, soybean, black gram and red mash as compared to inorganic farming **(Khurana and Kumar, 2020).** In survey of Karnataka, the farmers increased yields by 79% **(Khadse et al, 2018)** and in Andhra Pradesh increased yield is 88% **(Bharucha et al, 2020)** compared to 'non-ZBNF' management techniques. ZBNF inputs have also been observed to increase the growth and yield of chilli **(Gangadhar et al, 2020),** peppers **(Boraiah et al, 2017),** rice, groundnut **(Bharucha et al, 2020),** maize **(Vinay et al, 2020)** banana, gram legumes **(Galab et al, 2019)** and cotton **(Korav et al, 2020)** compared to non-ZBNF agricultural practices. The study was undertaken in Telegana state where the yield of maize in conventional farming was found to be higher than ZBNF and organic farming **(Vinay et al, 2020)** and another study found that rice yields were lower on ZBNF farms compared to non-ZBNF farms **(Galab et al, 2019)**. Andhra Pradesh is also India's largest producer of tomatoes, covering 167 thousand hectares **(Yesdhanulla and Aparna, 2018)** Therefore, the ZBNF treatment's 30–40% increase in the bulk of fruit yield from a single plant above organic and conventional could also have a sizable positive impact. The application of biodigester liquid manures to obtain higher yields of rice **(Siddaram, 2012)** and other field crops **(Reddy et al, 2010).** Panchagavya spray influenced significantly on yield of capsicum per hectare. Due to the use of liquid chemical formulations, yield per hectare of capsicum varied dramatically at different phonological phases **(Boraiah et al, 2017).** Fruits yield per hectare varied significantly due to the application of jeevamritha.

Second claim: Effect on Earthworm population

The second claim put forward by ZBNF promoters is that ZBNF practices enhance the activity of soil biology, and larger earthworm populations are an indicator of this. Prior studies have found that ZBNF farms have a higher abundance of earthworms than non-ZBNF fields. **(Bharucha et al, 2020).** In the research, earthworm abundance was indeed significantly and considerably higher in the ZBNF treatment than the conventional or organic treatment in all three seasons **(Duddigan et al, 2023).** Retaining crop residue, or dead mulch, on the soil surface can boost the earthworm population by reducing soil temperature, retaining moisture, and providing more food sources for the earthworms to grow and reproduce **(Turmel et al, 2015).** Additionally, it has been found that applying cow dung and Jiwamrita to the agro-industrial waste treatment process increases the number of earthworms **(Veeresh et al, 2013).**

Third claim: Effect on Microbial Activity

The third claim put out by the ZBNF promoters is that ZBNF practices enhance the activity of microbes. Natural farming proponents contend that native cow dung and a little amount of undisturbed soil contain a variety of microorganisms that help increase the bioavailability of nutrients to plants. The complex ecosystem that exists in soil includes bacteria, fungi, plants, and animals **(Bonkowski et al, 2009)**. Soil microbes metabolize recalcitrant forms of soil-borne nutrients to liberate these elements for plant nutrition. Most nutrients, including N, P, and S, are bound in organic molecules in natural ecosystems, which makes them only slightly accessible to plants. The development of soil microorganisms like bacteria and fungi, which have the metabolic apparatus to depolymerize and mineralize organic forms of N, P, and S, is necessary for plants to obtain these nutrients **(Jacoby et al, 2017).** The researcher has isolated many different bacterial genera such as Citrobacter koseri, Enterobacter aerogenes, Escherichia coli, Klebsiella oxytoca, Klebsiella pneumoniae, Kluyvera spp., Morgarella morganii, Pasteurella spp., Providencia alcaligenes, Providencia stuartii and Pseudomonas spp. from cow dung **(Sawant et al, 2007)**. This study found that many cow dung microorganisms have shown natural ability to increase soil fertility through phosphate solubilization **(Gupta et al, 2016)**. The researcher has isolated 219 bacterial strains from cow dung, among which 59 isolates displayed nematicidal activity against >90% of the tested nematodes **(Lu et al, 2013)**. Cow dung has antifungal substance that inhibits the growth of coprophilous fungi**.** The samples from natural farming fields, turmeric, as well as sorghum fields in Parbhani district, recorded higher mean population of actinomycetes, free-living nitrogen-fixing bacteria, phosphorus solubilizing bacteria (PSB) and Pseudomonas sp. but lower mean population of bacteria and fungi as compared to samples from Non-NF fields **(Kumar et al, 2020)** (Table 2).

Table 2. Average soil microbial population in turmeric and sorghum cultivated fields of Parbhani district, Maharashtra (Log10 CFU/g soil)

Particulars	Farming Type	Turmeric			Sorghum		
		Range	Mean	S.D.	Range	Mean	S.D.
Bacteria	**NF**	8.18-9.00	8.59	0.36	8.00-8.48	8.29	0.21
	Non-NF	8.30-9.64	8.82	0.53	8.78-8.95	8.87	0.07
Fungi	**NF**	3.00-3.65	3.45	0.26	2.70-3.65	3.32	0.44
	Non-NF	3.48-4.31	3.9	0.31	3.88-4.34	4.09	0.19
Actinomycetes	**NF**	3.00-3.54	3.29	0.19	3.00-3.60	3.2	0.28
	Non-NF	3.18-3.85	3.52	0.25	3.18-3.65	3.41	0.19
Free-living nitrogen-fixing Bacteria	**NF**	4.18-5.23	4.76	0.38	4.18-5.23	4.76	0.38
	Non-NF	4.40-5.31	4.92	0.35	4.40-5.31	4.92	0.35
Phosphorous solubilizing bacteria	**NF**	3.00-3.93	3.51	0.34	3.00-3.93	3.51	0.34
	Non-NF	3.18-4.13	3.76	0.36	3.18-4.13	3.76	0.36
Pseudomonas sp.	**NF**	5.00-6.06	5.67	0.41	5.00-6.06	5.67	0.41
	Non-NF	5.40-6.26	5.97	0.34	5.40-6.26	5.97	0.34

Table 3. Barriers to the growth of organic and natural farming.

why national and state governments do not fully support organic or natural farming.	why farmers are hesitant to use natural or organic farming methods.	Why most customers don't purchase natural or organic foods.
• Chemical-intensive farming mindset; • Scientific community is not focused on natural or organic farming; • Issues relating to food security and poor yield; • Influence of the agrochemical industry; • Organic and natural produce not consider a holistic solution beyond pesticide-free food; • Insufficient information on holistic linkages; • Minimal consideration given to the drawbacks of the present chemical-based model; • Lack of conviction regarding advantages; • Extension machinery is untrained, unpracticed, and lacking in expertise; • State-level 'political will' is not sufficiently demonstrated, with the exception of a few states like Sikkim and Andhra Pradesh.	• Dominant perspective on chemical farming; • Lack of knowledge of organic or natural approaches; • Lack of faith in natural and organic methods and concern over yield; • Inability to take risks and sustain yield losses; • Lack of handholding assistance while switching to organic and natural farming; • Lack of assistance and insurance throughout the switch to organic farming; • Lack of stable market with competitive prices; • Lack of sufficient supply of high-quality organic inputs, such as seeds, bio inputs, and technology; • Concerns about pest management; • Certification requires a lot of paperwork, which is time-consuming and costly for small producers; • Reliance on animals; • Labor-intensive and time-consuming are natural and organic farming practices; • Decline in rural youth interest in agriculture; • Diminished joint family support system.	• Organic produce is often priced higher than conventional most people are unable to pay higher prices; • It can be difficult to find and get organic food anywhere; • Concerns about credibility of organic food in market, i.e. whether produce is fake organic; • Lack of awareness or covinction about health linkages (e.g. cancer and pesticides have a more complex link than sugar and diabetes-this link is less direct, less seen and less believed); • Limited awareness on linkages of organic and natural farming with sustainability, environment etc; • Consumers and lack awareness of chemical-dependent food systems and food producers.

Benefits perceived by NF farmers

Farmers perceive many benefits of NF. In Andhra Pradesh, 81% farmers believe that the yield has increased (Table 4). In Karnataka, 56% of farmers felt lower yield in NF. NF practice reduces the cost of cultivation which is felt by 86% of farmers in Andhra Pradesh and more than 90% in Karnataka and Maharashtra. As far as produce quality and taste are concerned, around 90% in all the selected states found that NF produce has better quality than non-NF produce. In Andhra Pradesh, farmers are not getting any designated market for sale of NF produce, hence the produce in sold in the same market at almost same price. In Karnataka and Maharashtra, farmers are getting designated markets where produce fetches higher price.

Table 4. Benefits perceived by Natural Farming farmers (Kumar et al, 2020)

Perceived benefits	Percent farmers		
	Andhra Pradesh	Karnataka	Maharashtra
Crop yield			
High	81	22	60
Same	17	20	16
Lower	2	56	24
Cost of cultivation			
High	14	7	9
Low	86	93	91
Produce quality			
Better	96	89	91
Same	3	11	9
Poor	1	0	0
Taste of Produce			
Better	91	89	89
Same	9	11	11
Selling Price			
High	22	96	81
Same	69	4	19
Lower	1	0	0

Opportunities to adopt ZBNF

When it comes to the green revolution, the use of high-yielding cultivars, chemical fertilisers, and pesticides reduces soil health by removing a lot of nutrients from the ground, reducing the number of beneficial microbes, and accumulating harmful substances in the soil profile. It also contaminates groundwater. These all create a negative impact on the environment and human health. Organic matter is the primary source of plant nutrients as a result of crop residue burning, which lowers soil organic matter content and increases air pollution. Environmental sustainability is required in the context of this growing globalisation in order to protect the environment for the coming generations. Even though they don't make much money from it, farmers still have to deal with high input expenses in commercial

farming. Natural farming gives better opportunities to solve these problems in a better manner. Conserving nature- this practice improves microbial content and water retention capacity in soils which enables drought-prone areas to provide consistent yields. Less application of chemical fertilizers reduces runoff water into rivers and wetlands enhancing water quality and increasing availability during extreme weather events. Reduces health risks from chemicals entails ecosystems on the farms and reduces the drudgery of women who have easier access to clean water and feed for livestock as well as reducing illnesses caused by chemicals in food, especially among children. In addition to this, the social and environmental benefits are food, nutrition, and health security, employment, soil health, and water security, coastal ecosystem regeneration, climate resilience, biodiversity protection, and less risk. Indian Government allowing farmers to convert natural farming, the finance minister Nirmala Sitaram announced 687.5 crores to organic farming and natural farming development in the 2020-21 budget.

Public policies need for zero-budget natural farming

The change in the basis for public policy- To remedy improper resource usage, according to Ramanjaneyulu, a scientist at the Centre for Sustainable Agriculture, agriculture must transition to varied, biological resource-integrated models. Intercropping, different cropping systems, suitable crop rotations, and integrating crops and animals should all be adopted. Conscious planning of land use and farming systems is required, with the difficulties of ecological intensification being taken into consideration. It is crucial to maintain agronomic variety peculiar to each ecosystem. For instance, the practice of appropriate farming techniques needs to be supported in wetlands, rainfed areas, hill regions, etc. Current unsustainable agricultural models that are centralized and dependent on monocultures must be stopped. Strictly adhere to the rules and limit the use of unsuitable technology, such as agrochemicals, GMOs, and other technologies with potential concerns for biosafety. Increase the budgeted allocation from the union to ZBNF for appropriate agricultural investments by 10% to 15%. Farmers should have more informed options rather than being controlled by captive organizations. Providing for financial security requires that the Farmers Income Commission make sure the statutory commission balances decisions impacting production costs, subsidies, support costs, and the prices of produced goods. Setting the research and training agenda for agricultural research requires the adoption of an agroecological perspective. Researchers should adopt participatory methods that involve practicing farmers and farm workers and develop appropriate technologies to suit their needs.

Conclusion:

This study aimed to assess the performance of ZBNF against conventional and organic alternatives and to mechanistically explain the benefits ZBNF offers. In order to research ZBNF's effects on soil, land, and environment health, the socioeconomic condition of farmers, and the nation's food security, multi-locational trials by unbiased, independent bodies like ICAR are urgently required at this time. As a result of mulch addition, ZBNF treatment may result in higher yields, higher microbial activity, and larger earthworm populations. There is still a need for more research on the contribution of each of the ZBNF inputs (Bijamrita, solid Jiwamrita, liquid Jiwamrita, and mulch). Additionally, it will be

important to examine further the availability of these inputs if the system is operated at scale. In addition, while our research has concentrated on ZBNF amendments, other aspects of ZBNF management must be examined in the future, including intercropping and reduced tillage. Farmer profitability, human health, greenhouse gas emissions, biodiversity, and environmental quality are all adversely affected by the intensive use of synthetic pesticides and fertilizers. However, long-term field and landscape scale trials are needed to corroborate these observations if ZBNF is going to be adopted at scale.

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