Review Article

REVOLUTIONIZING AGRICULTURE WITH ZERO BUDGET NATURAL FARMING FOR A GREENER TOMORROW

ABSTRACT

The agricultural sector is fundamental to human civilization since it provides food and other basic needs to billions of people. Given that 9.7 billion people are expected to live on Earth by 2050, food production needs to increase by 70%. The population is predicted to become more urbanized by 2050, with 75% of people likely to live in metropolitan regions. Improved agricultural techniques and the promotion of high-yielding cultivars are essential to addressing the issues of sustainability and food security. The Green Revolution changed agriculture in India, resulting in a food surplus. However, it has resulted in difficulties such as lower crop output, resource depletion, and environmental deterioration. In response, new techniques such as zero-budget natural farming (ZBNF) have evolved. Subhash Palekar promoted ZBNF, which is a sustainable and cost-effective technique that prioritizes soil health, biodiversity, and farmer well being. Zero Budget Natural Farming (ZBNF) is a sustainable farming approach aimed at improving soil health, increasing crop output, and lowering production costs. The foundations of ZBNF are examined in this review study along with how they affect agricultural output, environmental sustainability, and socioeconomic advantages. ZBNF places a strong emphasis on using organic inputs and natural resources, such as Jeevamrita, Bijamrita, Acchadana, and Whapasa, to increase microbial diversity, improve soil fertility, encourage nutrient cycling, and save water. This review analyses that ZBNF can lower production costs, boost crop yield, and enhance soil health. Better emergence parameters, relative leaf water content, root parameters, and overall yield and productivity are among the benefits it confers on plant growth. Additionally, by encouraging sustainable agriculture, lowering greenhouse gas emissions, and improving rural lives, ZBNF supports the UN Sustainable Development Goals.

KEYWORDS – Zero Budget Natural Farming (ZBNF), Sustainable agriculture, Soil health, Crop productivity, Microbial diversity

INTRODUCTION

Agricultural sector is the major foundation of human civilization which provides food and essentials to billions of people on earth. The World's population is projected to hike about 9.7 billion people by 2050, and therefore, the food production levels need to be increased by 70 per cent to ensure the agricultural productivity and to regulate sustainability(Shubham *et al.*, 2023). Furthermore, 75% of the World's population is expected to reside in urban areas BY 2050 due to the World's growing urbanization (Anonymous, 2018). In order to meet the everlasting demands for food safety and security, ensuring food security becomes a major concern for country. Adoption of high yielding cultivars and improved farming practices with sound technologies can be an alternative for overcoming such issues (Shubham *et al.*, 2022). Green revolution technology has proven itself a double-edged sword for both the Indian agricultural sectors and worldwide. However, Indian agriculture sector has progressed from a food-scarce to a food-surplus country, it has faced various issues *i.e.* reduction in crop

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Comment [3]: Show quantitative data for ZBNF and conventional practices with synthetic or artificial substances like artificial fertilizer, pesticide etc.that were previously carried out.

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In the last decade, various crop management approaches like biofertilizers/biopesticides, vermicompost and farm yard manure (FYM) have been used to reduce the detrimental effects of chemical fertilizers and pesticides on soil (Ray *et al.,* 2020).Despite such scientific attempts, unfortunately there is still no established strategy for replacing the chemical-based fertilizers with long-term outcomes. Moreover, organic farming reduced the greenhouse gases (GHG's) emissions by about 65 per cent and mitigated the climate change. However, challenges such as low production and complex certification procedure are still remainedas major hurdles (Timsina and Can, 2018).Zero budget natural farming (ZBNF), a historic and traditional farming approach which has been reintroduced as a self-sufficient alternative to assist and to address these concurrent concerns. Zero Budget Natural Farming (ZBNF) was promoted by agriculturist Mr. Subhash Palekar in the mid-1990's. ZBNF has emerged as a sustainable and cost-effective agricultural practice that prioritizes soil health, biodiversity and farmers well-being. In the face of increasing global food demand and environmental challenges, the adoption of ZBNF offers a promising solution to enhance the agricultural productivity along with preserving the natural resources.The approach of ZBNF relies on the exemption of external sources like synthetic fertilizers and pesticides and therefore cutting the cost to almost zero. Additionally, crops are grown without the use of chemicals, utilizing natural resources like cow dung and urine among others (Bharucha *et al.,* 2020;Timsina and Can,2018;Khadse *et al.*,2021).Activity of earthworms and microbial populations are found to be increased multiple times with the ZBNF formulations like Jeevamrit, Beejamarit and Panchgavya. Incorporation of these formulations in soil boosts the soil nutrients availability, fortifies the resistance mechanism and ultimately raises the crop yield (Ray *et al.*, 2020;Maduka *et al.,* 2019;Patel *et al.,* 2021).

Recent research on ZBNF by Niti Ayog in the Indian states *i.e.* Andhra Pradesh, Maharashtra and Karnataka showed that under the irrigated and rainfed conditions, the overall cost of cultivation was found to be dropped by 23.7 per cent, however the yield, gross and net revenue was improved by 14.2 to 50 per cent(Kumar *et al.,* 2020).Therefore, after such a reliable result, number of states including Himachal Pradesh, Uttar Pradesh, Haryana, Gujarat, Tamil Nadu and Kerala are shifting towards this farming approach(Khadse and Rosset, 2021).ZBNF is likely to handle sustainability, resource conservation, global warming and other concerns from a suitable perspective (Munster *et al.,* 2018). Therefore, it presents itself as an effective solution to the serious and major problems of modern agriculture era, and in addition, providing a practical and affordable strategy which aims to increase thecrop productivity without harming the environment. Therefore, the present review majorly explores the pillars of ZBNF and its impacts on agricultural production, environmental and socio-economic benefits.

ZERO BUDGET NATURAL FARMING(ZBNF)

ZBNF approach was introduced by Mr. Subhash Palekar. His keen interest in field experiments showed that how constant chemical usage is affecting the soil fertility and turning the area barren (Jannoura *et al.,* 2014). As the name implies, ZBNF is a farming practice in which there is no expenditure oriented for the cultivation and harvesting of plants.

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Therefore, it means farmers will save money on fertilizers and insecticides in order to keep their crops healthy. ZBNF approach reduces the amount of money farmers have invested. It also helps to prevent the soil from degradation and desertification. It aims to encourage traditional indigenous techniques which lessen the demand for foreign inputs. It focuses largely on on-farm biomass recycling with a particular emphasis on biomass mulching, on-farm formulations of cow dung-urine, frequent soil aeration and the avoidance of synthetic chemicals. In essence, ZBNF is entirely dependent on the exclusive use of plentiful natural resources, just as ancient agriculture was. As ZBNF improves soil health through biodiversity, microbial activities, nutrient recycling and beneficial biological interactions, it is becoming more popular at a time when production costs are rising sharply, production rates are stagnating and environmental footprints associated with chemical pesticides and fertilizers are increasing. This leads to sustainable crop production (Moss and Bittman, 2018).

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This approach has the potential to boost the rural economies and lowering the farmer's credit risks associated with chemical farming, which uses a lot of resources. Additionally, it will enable farming households to save more money for necessities like financial stability, healthcare and education. The Andhra Pradesh government gave Rythu Sadhikara Samstha (RySS), a state-owned nonprofit organization, an order in 2015 to expand ZBNF practices to encompass all six million farmers and eight million hectares of agricultural land in the state by 2024. The initiative seeks to support ecological, chemical-free and climate-resilient agriculture in the face of agrarian distress and to give small and marginal farmers lucrative agricultural incomes. The initiative was introduced in 2015–16 and in 2016–17 it began to be implemented in the field. In the 13 districts of Andhra Pradesh, as of July 2019, approximately 500,000 farmers had registered for the program, totalling over 2,04,000 acres. Large-scale execution of this initiative might contribute significantly to India's progress toward nearly 25 per cent of the 169 SDG objectives (Tripathi *et al.,* 2018).

FOUR PILLARS OF ZBNF

ZBNF is based on its "four wheels": Whapasa, Bijamrita (treating seeds), Jivamrita (inoculating soil) and Acchadana. Two of them are microbial combinations that can be made in less than 48 hours, that is Jivamrita and Bijamrita (Khadse and Rosset, 2019). In order to release the soil's natural nutrients through Jivamrita, the notion of "Annapurna" was presented. This idea states that each farm family does not need to possess a cow because one cow's dung and urine are enough to cultivate the thirty acres of land (Anonymous, 2018).

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1. Jeevamrita

A fermented microbial culture which acts as a catalyst and promotes the soil microbial activity, increase the number of native earthworms in soil and also enrich soil by supplying nutrients. For the production of jeevamrita, one need to fill the barrel with 200 litres of water, add 10 kg of fresh cow dung from the area, 5 to 10 litres of old cow urine, 2 kilogram of jaggery, a sort of brown sugar from the area, 2 kg of pulse flour and a handful of dirt from the farm's bund. Give the mixture a good stir, then let it to ferment in the shade for 48 hours. jeevamrita is ready for use. One acre of ground may be sufficiently covered with 200 litres of jeevamrita. Over the course of the 48-hour fermentation process, the anaerobic and aerobic bacteria present in cow dung and urine proliferate as they consume organic ingredients (such as pulse flour and jaggery). Native species of bacteria and organisms are inoculated by a little amount of undisturbed soil. Additionally, jeevamrita aids in the prevention of bacterial and fungal plant diseases. It should be applied to the crops twice a month using irrigation water or

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a 10 foliar spray. The preparation is kept in storage for a maximum of 15 days. jeevamrita is administered to the individual plant in horticultural crops. Most of the sample farmers in Maharashtra are using the drip irrigation method to apply jeevamrita. Using jeevamrita enhanced agricultural yield and encouraged the growth of beneficial soil microorganisms (Shaikh and Gachande, 2015).

2. **Bijamrita**

Bijamrita is a locally produced microbial seed treatment suitable for seeds, seedlings and other planting materials. It is made using components similar to those found in jeevamrita. It is effective in preventing fungal growth on early roots and protecting seedlings from illnesses spread by seeds or the soil (Khadse *et al.*, 2017). It helps to stimulate plant development in addition to acting as a plant protector. The same elements used to make jeevamrita are used in its preparation: lime, water, soil, and locally produced Indian cow dung and urine. In particular, five litres of cow urine and 5 kg of cow dung are put into a container that holds 20 litres of water. After that, a fistful of local soil and 50 grams of lime are thoroughly combined with it. Before the seed is placed in the ground, it has to be soaked in bijamrita, covered, and planted (Anonymous, 2016).

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3. **Acchadana**

Mulching is the term for acchadana. Applying a layer of mulch to the soil is known as mulching. Mulching is yet another crucial ZBNF element. A certain ecosystem is necessary for the optimal growth, reproduction and activity of jivamrita's helpful bacteria. Three methods are used to supply this environment: soil mulching, live mulching and mulching with straw. Mulching is a useful technique for raising crop quality and production, because it keeps the soil wet, regulates temperature and reduces evaporation (Chakraborty *et al.*, 2008).

Types of mulching

a) **Soil Mulching:** This kind of mulching is intended to prevent tilling from destroying topsoil during farming by enhancing aeration and water retention in the soil. It is suggested to avoid deep ploughing.

b) **Straw Mulching:** Straw material is the term used to describe dried biomass waste from previous crops. Microbial cultures and the soil biota stimulate the organic materials as they break down and ultimately turn into humus.

c) **Live Mulching:** It is essential to construct various cropping patterns for monocotyledons and dicotyledons planted in the same region in order to supply the necessary nutrients to the soil and crops. Plants in the dicot group, which includes pulses, fix nitrogen. Monocots like wheat and rice provide additional elements including phosphate, sulfur and potash.

4. **Whapasa**

Palekar proposed that plants should only take up water vapor, not liquid water. He thus advised us to cut back on irrigation and advised using very little water in alternate furrows alone. It lessens the need for excessive watering, keeps the soil's moisture profile favourable and enhances the soil's quality (Bharucha *et al.*, 2020). Mulching prevents rainwater from evaporating too rapidly in regions that get rainfall. It may reduce water use by 90 per cent and is especially beneficial in locations that receive rain.

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EFFECT OF ZERO BUDGET NATURAL FARMING ON SOIL

Improved Soil Fertility:

ZBNF encourages the use of organic and natural inputs such agricultural leftovers, cow dung, and urine, as well as other locally accessible resources. By adding necessary minerals to the soil, such as potassium, phosphorus, and nitrogen (NPK), these inputs improve soil fertility. The addition of mulch and other organic inputs raises the amount of organic matter in the soil through organic matter enrichment. As a result, there is an increase in nutrient availability due to improved soil structure, water-holding capacity, nutrient retention, and beneficial microbial activity (Ghosh *et al.*,2017)

Enhanced Microbial Diversity:

Use of Jeevamritha (fermented microbial culture), one of the ZBNF techniques, cultivates beneficial microorganisms in the soil. This improves microbial variety, which is important for the cycling of nutrients, the prevention of illness, and the general health of the soil. Better soil aeration, nutrient availability, and enhanced soil structure are all facilitated by increased microbial activity in the soil, which results in healthier and more productive soils. The research stated that there is increase in Proteobacteria, and bacterial phyla including *Bacillus*, *Pseudomonas*, *Rhizobium*, and *Panibacillus* (Saharan *et al.,* 2023).

Nutrient Cycling:

One essential element of ZBNF is intercropping, which encourages soil nutrient cycling. By ensuring that vital nutrients are accessible to the crops, this approach helps prevent nutrient imbalances and depletion.The research demonstrated a significant increase in available potassium, accessible phosphorus, and organic carbon in the soil increases of up to 46%, 439%, and 142%, respectively. Moreover, there were notable improvements in micronutrients including manganese, iron, copper, and zinc, which increased to 98%, 23%, 62%, and 55%, respectively (*Saharanet al.,* 2023). ZBNF stimulates nutrient recycling mechanisms in the soil, lowering the need for outside inputs and improving long-term soil fertility by upholding a balanced ecosystem and encouraging biodiversity (Kumar et al., 2019)

Water Retention and Moisture Conservation:

One of the four pillars in ZBNF is Acchadana, which is frequently done in ZBNF, improves water penetration, lowers evaporation, and controls soil temperature to assist or maintain soil moisture. This guarantees a steady supply of water for crops, particularly in areas where water is scarce. Effective water management techniques, such as rainwater collection and drip irrigation, are promoted in ZBNF to assist save water resources and satisfy the unique moisture requirements of crops without wasting them. Natural farming is a highly effective approach that has been shown to increase water retention capacity. It needs minimal water usage and is known to lessen reliance on resources such as water and power. As a result, groundwater reserves will be preserved, water tables will improve, and farmers will have less financial and labor stress. Whapasa practices help to improve soil fertility and water use efficieny.(Kumar *et al.*,2020)

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EFFECT OF ZERO BUDGET NATURAL FARMING ON PLANTS

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Emergence parameters:

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In comparing Zero Budget Natural Farming (ZBNF) treatments, specifically ZBNF combined with Minimum Tillage, Mulching, and Intercropping, it shows higher emergence count and emergence velocity. This suggests that ZBNF methods might encourage early plant establishment and improved seed germination (Sreenivasa *et al.*,2010).

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Relative Leaf Water Content:

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Compared to plants grown under conventional tillage practices, plants subjected to Zero Budget Natural Farming (ZBNF) treatments—including ZBNF combined with Minimum Tillage (MT), Mulching (M), and Intercropping (IC)—displayed noticeably higher relative leaf water content throughout all growth stages. This data suggests that ZBNF techniques may be able to maintain more appropriate water levels in plant tissues, which may result in improved plant performance and health (McMillen, 2013).

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Root Parameters:

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In research, plants cultivated using Zero Budget Natural Farming (ZBNF) treatments—that is, ZBNF in conjunction with Minimum Tillage (MT), Mulching (M), and Intercropping (IC)—produced the highest root mass and length densities when compared to plants grown using traditional tillage techniques. This result emphasizes how ZBNF procedures might encourage strong root growth. Plants require a well-developed root system in order to efficiently absorb nutrients and water, which lays the groundwork for healthy development and increased resistance to environmental challenges (Yang *et al*., 2018).

Yield and Productivity:

Zero Budget Natural Farming (ZBNF) has become a very promising agricultural strategy that greatly increases yields in comparison to conventional tillage methods, particularly when combined with Minimum Tillage (MT), Mulching (M), and Intercropping (IC). These techniques work in combination to produce a favourable environment for plant development and increased yield. ZBNF gradually contributes to improved soil health by removing artificial inputs and depending only on natural resources. This is a critical improvement since healthier soils hold on to more water and nutrients, which promotes healthy root development and overall plant growth (Parihar *et al*., 2018; Shao *et al*., 2016).

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IMPACT OF ZERO BUDGET NATURAL FARMING ON SUSTAINABILITY GOALS

In addition to potentially helping millions of farmers and their families worldwide, the Zero Budget Natural Farming (ZBNF) effort might make a major contribution to the UN Sustainable Development Goals (SDGs). N. Chandrababu Naidu, the Andhra Pradesh chief minister, and Erik Solheim, the executive director of the United Nations Environment

Programme, announced the results. The research maps the possible social, economic, and environmental impacts of the ZBNF program to the specific goals of the SDGs. The ZBNF farmers in Andhra Pradesh have stopped using artificial pesticides and fertilizers in favor of natural farming practices.Instead, according to the release, they employ inexpensive, naturally produced mixtures, inoculums, and decoctions created from cow dung, cow urine, jaggery, lilac, green chilies, and a number of other similar natural components, all of which are acquired locally.

Table 1. This table demonstrates the sustainable developmental goals and it's impact on SDG

Sustainable Development Goals	**Impact on SDG**
SDG 1 (End Poverty)	Considerably reduced input costs and increased yields. Their net earnings are higher as a result.
SDG 2 (End hunger, food security, improved nutrition, and promote sustainable agriculture)	By giving all small-scale food producers fair and safe access to land, we can double agricultural output and profits. Use reliable techniques and make sure food production systems are long-lasting. Funding for rural infrastructure, extension services, and agricultural research should all be increased.
SDG 3 (Health lives and promotes well-being for all)	Encourage mental wellness and well-being while reducing the early death rate from noncommunicable diseases by one-third. Cut down on the amount of illnesses and fatalities caused due to contaminated soil, water, and air as well as hazardous components and other aspects.
SDG 4 (Ensure inclusive and equitable quality education)	Increase the percentage of adults and youth who possess the abilities needed for gainful employment, entrepreneurship, and respectable jobs. Make sure that each student has the abilities and information required to promote sustainable growth.
SDG 5 (Gender equality and empower all women and girls)	Reforms to guarantee women's equal access to natural resources, land sovereignty, and economic resources. Increase the way that enabling technology is used to support women's empowerment.
SDG 6 (Ensure availability and sustainable management of water and sanitation for all)	To enhance water quality, decrease untreated wastewater, minimize pollution, reduce hazardous chemical emissions, and boost recycling and safe reuse. Protect and restore aquatic ecosystems.

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SDG 7 (Affordable, reliable, sustainable and modern energy for all)	By eliminating the use of chemical pesticides and fertilizers, ZBNF will drastically reduce the amount of energy required along their value chain.
SDG 8 (Encourage inclusive, long-term economic growth and the creation of employment)	Maximizing the effective use of resources in both production and consumption, and keeping environmental damage apart from growth. Ensure that everyone, especially the youth, is fully and productively employed and doing high-quality work.
SDG 9 (Reliable infrastructure, encourage equitable and environmentally friendly development)	Businesses should adapt resource-saving strategies and environmentally friendly practices and infrastructure should be upgraded in order to make them more sustainable.
SDG 10 (Reduce inequality within and among countries)	Aiming to achieve and maintain income growth rates for the poorest 40% of the population that are higher than the national average
SDG 11 (Cities and human settlement inclusive, safe, resilient, and sustainable)	Limit the number of people affected and the financial losses brought on by catastrophes, especially those involving water, with an emphasis on the weak and disadvantaged. Compared to non-ZBNF plots, ZBNF farmlands could be more resilient to flooding, severe winds, and droughts.
SDG 12 (Ensure sustainable consumption and production patterns)	Ensure sustainable and effective management of natural resources. Achieve environmentally sound waste management for all wastes, including chemicals, and restrict their release into the air, water, and soil in order to minimize any unfavorable consequences. Use prevention, reduction, recycling, and reuse to lessen the amount of waste produced. Promote the application of moral public procurement procedures. Make sure everyone is aware of the environment and knows how to live sustainably.
SDG 13 (Take urgent action to combat climate change and its impacts)	Strengthen the ability and resilience of the world to withstand natural catastrophes and risks associated with climate change.
SDG 14 (Seas, oceans, and marine resources should be preserved and used responsibly for	Prevent and minimize marine pollution, especially that which is brought on by

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sustainable development.)	activities that are done on land, such as the contamination of nutrients and debris. Take steps that will mitigate the impacts of ocean acidification.
SDG 15 (Combat desertification, preserve, restore, and encourage the sustainable use of terrestrial ecosystems, manage forests responsibly, stop and reverse land degradation, and stop the loss of biodiversity.)	Ensure that wetlands, mountains, drylands, forests, and other terrestrial and inland freshwater ecosystems are preserved, restored, and utilized sustainably. Prevent desertification and restore land and soil that have been harmed by floods, droughts, and other natural calamities. Minimize the destruction of natural area habitats, stop the decline in biodiversity, and prevent the extinction of fragile species.
SDG 16 (Encourage open and peaceful societies for long-term growth, guarantee everyone's access to justice, and create inclusive, responsible, and successful institutions at all levels.)	Make ensuring that decision-making is responsive, inclusive, participatory, and representational at all levels.
SDG 17 (Increase the Global Partnership for Sustainable Development's implementation strategies and resuscitate it.)	Establishing multistakeholder partnerships that mobilize and share knowledge, expertise, technology, and other resources helps improve international cooperation for sustainable development.

Source: (Tripathi *et al.*, 2018)

CONCLUSION

In conclusion, this review highlights Zero Budget Natural Farming (ZBNF) as a transformative agricultural system with significant implications for sustainability and resilience. ZBNF promotes soil health and an ecosystem that flourishes in agricultural settings by prioritizing the use of natural resources such as Jeevamrita, Bijamrita, Acchadana, and Whapasa, as well as organic inputs. The emphasis on soil aeration, on-farm biomass recycling, and the avoidance of synthetic pesticides demonstrates ZBNF's commitment to regenerative measures that promote soil fertility and productivity over time. Additionally, ZBNF's cost-effectiveness allows farmers to save money on pesticides and fertilizers which helps both individual farmers and the greater goal of sustainable agriculture. Due to its capacity to reduce production costs, boost crop yield, and enhance overall productivity, ZBNF seems to be able to address two issues which are food security and environmental sustainability. ZBNF's compatibility with the UN Sustainable Development Goals demonstrates its ability to encourage progress in a broad range of areas, including poverty reduction, climate action, and sustainable agriculture. ZBNF represents an integrated strategy to agricultural development that prioritizes the welfare of the land and people by advocating for resource conservation, greenhouse gas emissions reduction, and rural life enhancement.
By embracing and applying the ZBNF principles into agricultural policies and practices, we may create a more resilient, equitable, and environmentally sensitive future for future generations. However, further scientific research and assessment are urgently required before

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recommending this procedure. Several researchers propose that the effectiveness of ZBNF may be area, agro-climatic zone, or soil-specific. Multi-location trials are necessary to accurately assess the effectiveness of ZBNF in various soil types and agro-climatic zones.

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Comment [43]: Be consistent with your reference style. About 6 references are listed here but not cited in the work. These are highlighted in red.

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