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# Review- Zero Budget Natural Farming a Key to Sustainable Agriculture: Challenges, Opportunities and Policy Intervention

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**ABSTRACT**

*Sixty percent of the Indian population will experience severe food deficiencies by 2050. Increased food production is urgently needed, but the high cost of production, fluctuating prices in the market are driving farmers into debt. Zero budget natural farming (ZBNF) is the best solution to reduce the input cost of farmers. The word zero budget means "no credit" and natural farming means "growing of crops without chemicals". 1st time in the world, Japanese agriculturist M Fukuoka developed natural farming and the same trend was made in India by Mr. Subhash Palekar, he started the ZBNF concept and made successful in south India. 523,000 farmers have already converted to ZBNF in Andra Pradesh and 1 lakh farming houses in Karnataka. This concept works on four concepts they are jeevamrith, bijamrith, mulching, and soil aeration. These four concepts help better soil health, increased microbial population, and enhanced crop yield. Different astras used to control pest infestation in natural farming. Here we discussed ZBNF is requires low input cost, good soil health management, and focused on major challenges and opportunities to adopt ZBNF and what are the policies need to improve this system.*

***Keywords:*** *Soil health, Astras, Credit, Input, Jeevamrith, Chemical, Yield*

## INTRODUCTION

Modern chemical-based agriculture now a day's increased the cost of production or reduced crop yield due to various reasons (Intawongse & Dean, 2006; Ayansina & Oso, 2006; Sreenivasa et al. 2010; Singh et al. 2011). Growing of commercial same crop year after years such as rice, wheat, cotton, and sugarcane results in the depletion of soil fertility, topsoil infertile, soil vitality, groundwater, and mostly on soil beneficial microbes population.

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Continues use of chemical fertilizer, crop residue burning, and pesticide application can cause environmental pollution worldwide. There continues usage, decreased the soil micro and macrofauna which may directly affect on C-N ratio and nitrification activity (Jenkinson, 1982; Doran et al. 1996; Shaikh & Gachande, 2015). Heavy use of pesticides and chemical fertilizers can contaminate in the soil profile and leached down to enter into groundwater especially heavy metals like Cd, Cu, Mn, and Zn. Uptake of this heavy metal by plants holds in sink parts for a longer time. Peoples who consume these plant products suffer serious health problems (Byrnes, 1990; Barabasz et al. 2002). Among the heavy metals, cadmium and lead are high accumulation potential and toxic Wolnik, (1983). Crops such as carrot, spinach, lettuce, radish, and other leafy vegetables accumulate more heavy metals (Cobb et al. (2000; Mattina et al. 2003; Hough et al. 2004). The soil root zone contains various microbial communities which are beneficial effects on crop productivity. They are- plant growth-promoting rhizobacteria (PGPR), mycorrhiza, and cyanobacteria are promoting plant growth and development also protect against pathogens (Glick, 1995). Continues use of herbicides like atrazine and metolachlor decreased the soil microbial population. Most of the Indian farmers belong to marginal and small landholding category. If they invest more money to purchase inputs and not get satisfactory yield due to enabling to manage the incidence of pests and diseases and also adverse climatic conditions lead to an increase in the cost of production. It may be the reason to suicide of most of the farmers in India. Increasing the global population and economic growth are resulting in quickly increasing demand for food especially in developing countries which means low to middle-income countries such as India. The present population of India is 17.87 % (world meter UNDESA, 2020) of the total world population. As per the UN Department of Economic and Social Affairs, 2013 it is predicted to increase 1.2 billion (2010) to 1.6 billion (2050) population of India which is equivalent to 10 % of people over on the earth (Smith et al., 2020). To fulfilling of this population hungry, India should increase crop production by different farming practices. Increased yields per unit area and cultivation of more land are the two principals followed in 1961-1999. Similarly, increased use of synthetic fertilizers and irrigation water since the green revolution in India has resulted in inefficient use of natural resources (Agoramoorthy, 2008) mainly in north India which showed low nutrient use efficiency (Bruinsma, 2003). Around 16 % of India's land area having potential conservation to agriculture and remaining unsuitable for cultivation. Therefore to meet food scarcity in a populated area, crop production efficiency must be increased. According to NSSO data, agricultural households almost 70 % are spend more than they earn and more than half of all farmers are in debt. In States such as Andhra Pradesh and Telangana, levels of indebtedness are around 90 %, where each household bears an average debt of ₹1 lakh. Considering these issues, many alternatives and began looking at ancient farming practices for guidance but obviously without scientific validation and understanding of both the strengths and weaknesses of traditional Indian farming. Meanwhile, particularly NITI Ayog (Government of India), realizing the declining productivity and profitability of the small and marginal farmer's has been looking for alternative farming systems so that could be more decreased inputs and cost with profitable. Some of the alternative methods are Agnihotra Farming, Amrutpani Farming, Vedic Farming, Homoeo Farming, and Zero Budget Natural (Spiritual) Farming claiming exciting but scientifically unproven these farming results. One of these farming standing aggressively in the states of Karnataka, Andhra Pradesh, and Maharashtra is the Zero Budget Natural Farming (ZBNF) even govt of India also looking these farming technique. Anyway, before conclusion regarding promoting or depromoting of any of these farming technology, need to undertake their scientific evaluation, challenges, and opportunity and likely that impact on food security of the country.

**Zero budget natural farming**

The word zero budgets mean no credit or no expenses, without any credit and without spending any money on purchased agricultural inputs. Another term natural farming is a method of chemical-free agriculture drawing from traditional Indian practices. In other sense, natural farming shows the importance of the synergistic effect of both plant and animal products on crop establishment, to build soil fertility and microorganisms (smith et al., 2020). Natural farming is working with nature produced good food, and keeping healthy over selves, it is also known as do-nothing farming because the farmer is considered as a facilitator and the real work can be done by nature. No-tillage, no chemical fertilizer, no pesticides in this farming. 1st time in Japan, M Fukuoka started work on natural farming, and his results showed that yields from natural farming are similar to chemical farming but without soil erosion also maintains soil fertility for a longer time (Devarinti, 2016). There are no external inputs to his experiments and he used locally available on farm products are used. That's why he got zero or negligible cost of cultivation. His results compiled in a book one straw revolution. Natural farming minimizes the external inputs to farmland which degenerate the soil nature, increases microbial population better soil aeration and good water retention capacity (Fukuoka, 1978; Andow & Hidaka, 1998; Neera et al. 1992). Controlling of cabbage worm and cabbage moth 1st time he extracted natural insecticide like pyrethrum from chrysanthemum roots and used in his experiment got success on it.

Padma Shri recipient Mr. Subhash Palekar 1st time adapted this zero budget natural farming system in the Indian 1990s which is an alternative to the Green revolution. He was agriculturist belongs to Maharashtra completed his bachelor's degree in agriculture. He argued that the rising cost of these external inputs in farmland was a leading cause of indebtedness and suicide among farmers in India, and the impact of chemicals and pesticides burning of residues are on the environment and long-term fertility was devastating. So he concentrated on low input use technologies in agriculture that should be on-farm resources available within farmland and that should not harmful to soil health. For the 1st time, he has started the natural farming concept in Karnataka which was a neighboring state to him. He has converted over 50 lakh farmers into practicing what he prefers to call 'Zero Budget Natural Farming (ZBNF) in various states of India. This method promotes soil aeration, minimal watering, intercropping, bunds, and topsoil mulching with crop residue and strictly prohibited intensive irrigation like flooding and deep plowing tillage practices. Mr. Palekar is against vermicomposting, because of its main component of organic farming and these composting worms like *Eisenia fetida* commonly called as European red wiggler introduced to India these worms absorb toxic metals and pollute groundwater and soil. Strict ZBNF differs traditional organic farming, some points are listed in table no.1.

Karnataka where it was started 1st time in 2002 (Khadse et al., 2019), FAO suggests that one lakh farming households are already following zero budget natural farming (Bruinsma, 2003). Initially, it was got more popularity in southern states and more practiced in Andra Pradesh, Kerala, Uttarakhand, Himachal Pradesh, Chattisgarh, and Telangana. As per the official website of the ZBNF program, by August 2019, Andra Pradesh was 204,000 ha of land over 3,015 villages of 523,000 farmers converted had to ZBNF (RySS, 2018). Also, Andhra Pradesh planed to become Indias 1st state to practice 100 % natural farming by 2024. It aims to phase completely removal of chemical farming over 80 lakh hectares of land, converting the State's 60 lakh farmers to ZBNF methods. Millions of farmers converting nationwide to this farming and Prime Minister Narendra Modi recently told the UN conference on desertification that, in the future, India will focus on ZBNF (The Hindu, 2019; GEF, 2019). This ZBNF worked on four basic pillars are explained below.

**Table 1: Difference between organic farming and natural farming**

| Sl. No. | Organic farming | Natural farming |
|---|---|---|
| 1 | Manures like FYM, oilcake, Organic fertilizers compost-vermicompost, dung manure, dung slurry, etc. are used and added to farmlands from external sources. | Decomposition surface retained crop residues as organic matter by microbes and earthworms is encouraged, which gradually releases nutrition in the soil, over the period. |
| 2 | Still, it requires basic agricultural practices like plowing, tilting, mixing of manures, physical weed management, etc. to be performed. | There is no plowing, no tilting of soil and no fertilizers, and no weeding is done just the way it would be in natural ecosystems. It replaced by growing of intercrop, mixed crop mulching, etc. |
| 3 | It is still expensive due to the requirement of bulky organic manures as an external source, and it has an ecological impact on surrounding environments | There is no external source and one of the extremely low-cost farming methods, completely molding with local biodiversity. |
| 4 | It affects the surrounding environment | It does not & well adopt with local biodiversity, eco-friendly. |
| 5 | Certification is mandatory when selling organic products | No need for certificates to grow and sell natural farming products |
| 6 | Conversion of land from chemical farming to organic requires more 3 to 6 years depends on soil health | There is no period to converting chemical farming to natural farming but yield stability or gaining benefit starts after the 3-year cycle. |

**Pillars of ZBNF**

Concerning soil fertility, soil microbes play an important role, they involve in a nutrient cycle like C & N cycle which are required for plant growth (Lazarovits, 1997). Four main pillars run the ZBNF cycle that is listed in fig.1 (Palekar, 2014).

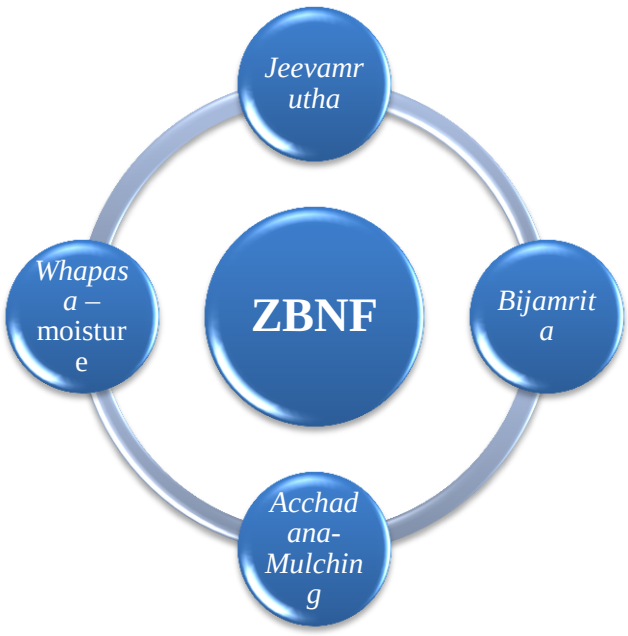


**Fig. 1: four pillars of ZBNF system**

**1. Jivamrita/Jeevamrutha:**

Microorganisms play an important role in the conversion of unavailable forms of nutrients to available form in the plant root zone. The microbes present in jeevamrutha helps non-available form to dissolved form when it is inoculated into the soil. It also helps as antagonism to (biological control) pathogens (Glick & Bashan, 1997). PGPR, cyanobacteria, and Solubilizing Bacteria (PSB), mycorrhizal fungi, Nitrogen-fixing bacteria are some important microbes present in the product (Chen et al.,1995). it requires 20 kg cow dung, 5-10 l urine, 2 kg dicot flour are well mixed and this add-in irrigation tank at regular intervals of 15 days until the soil is enriched or spray 200 l of jeevamruth twice in a month. It provides nutrients, microbial population, and helps to prevent fungal and bacterial plant diseases. It requires only 1st three years cycle after that system that self-sustaining. According to Mr. Palekar, only one cow is needed for 30 acres of land that should be a local desi cow not imported Jersey or Holstein because of imported cow dung and urine contains more pathogens and desi cow dung contains 300 to 500 crores of effective beneficial microbes.

**2. Bijamrita:**

It is composed of 20 l water, 5 kg cow dung, 5l urine 50 g lime, and a hand full of soil are thoroughly and store in a tank. It is used as a seed treatment, contains naturally occurring beneficial microorganisms. Research studies showed that inoculating with bijamrith to protect the crop from harmful soil-borne pathogens and young seedlings roots from fungus and soil-borne and seed-borne diseases also help to produce IAA and GA3 (Sreenivasa et al., 2010).

**3. Acchadana/Mulching:**

Mulching is of three types followed, they are straw mulch, soil mulch, and live mulch. The growth of cover crops like legumes helps to reduce the weed population and increases water infiltration capacity. By their root nodules fixes atmospheric N into the soil which helps N supply to crops. From these residues retention on the surface of soil increases the microbial degradation process and liberation of N from nitrification. It also supplies organic matter to the soil which contains many micro and macronutrients. Improves seed germination without soil plowing, reduce soil temperature in extreme condition, and increase soil temperature during winter. It conserves soil moisture by reducing evaporation loss of water from the soil layer and retains water for a longer time.

**4. Whapasa –aeration:**

The main concern here is conserving water and the precise application of water-based on crop water requirement. Application of water in alternative furrows because of all roots of plants not absorb efficiently, younger horizontal and vertical roots absorb more amount of water than older one and nutrients by older roots. In soil, out of soil mineral and organic matter, there is an equal proportion of water and air present. If a higher amount of water application leads to hold air space in the soil and plant suffers oxygen deficiency it may lead to cause death of plants except water-loving plants like rice. The soil aeration also an important parameter to plant growth so application interval should be longer.

**Benefits of ZBNF**

- The cost of production in ZBNF is zero as farmers don't require buying any inputs.
- It consumes only 10 percent of the water that crops consume in conventional methods.
- One cow can produce 10-12 kg fresh dung and it is sufficient to 30 acres of land in one month.
- Higher significant yield found under ZBNF in different cash as well as food crops E.g. 11 % and 40 % high yields of cotton and gulli ragi in ZBNF plots than in non-ZBNF plots.
- Farm input costs are nearly zero or negligible as no fertilizers and pesticides are used.
- ZBNF farms were able to withstand a long time under drought and flood situations.

- Planting more crops and border crops on the same piece of land provide extra dividend and as nutrient sources.

Overall concerning about ZBNF, there is reduced use of water and electricity bill, improved farmers health, maintaining local ecosystems and biodiversity, not leave any toxic residue in the environment, improvements in soil, biodiversity, livelihoods, water, climate resilience, women's empowerment and nutrition

**Pest management**

Crops are damaged by pests and diseases about most of the yield loss by weeds followed by pests and diseases (represented in fig.2). Controlling of this loss is also a big challenge in natural farming. Plant extractions are used to make a compound that kills or controls the pest population in the crop field. Some of plant protections are made by using a mixture of butter milk, cow milk, pepper powder, neem seed and green chilli (Palekar, 2016). Some research papers found some naturally extracted chemical-free compounds are explained below. They are,

**1. Agriastra:**

It consists of local cow urine (10 l), tobacco leaves (1 kg), green chili (500 g), local garlic (500 g), and neem leaves pulp crushed in cow urine (5 l) store it in a cool place. Take 2 l per 100 l of water and spray on crops. It effectively controls the pests like Leaf Roller, Stem Borer, Fruit borer, Pod borer

**2. Brahmastra:**

It is 2nd way to control the pest population in natural farming, it can be made by collecting different plant leaves like neem leaves, custard apple leaves, lantern camellia leaves, guava leaves, pomegranate leaves, papaya leaves, and white datura leaves are crushed and boiled with urine finally make filtration. After filtration, the extractant can store for longer use. It is most effective against all of the sucking pests, pod borer, fruit borer, etc.

**3. Neemastra:**

By using 5 l of local cow urine, 5 kg cow dung, 5 kg neem leaves 5 kg of neem pulp mixed well, and keep to airtight for 24 hours for fermentation. After the fermentation process is ready to use. Mainly controls sucking pests & Mealy Bug.

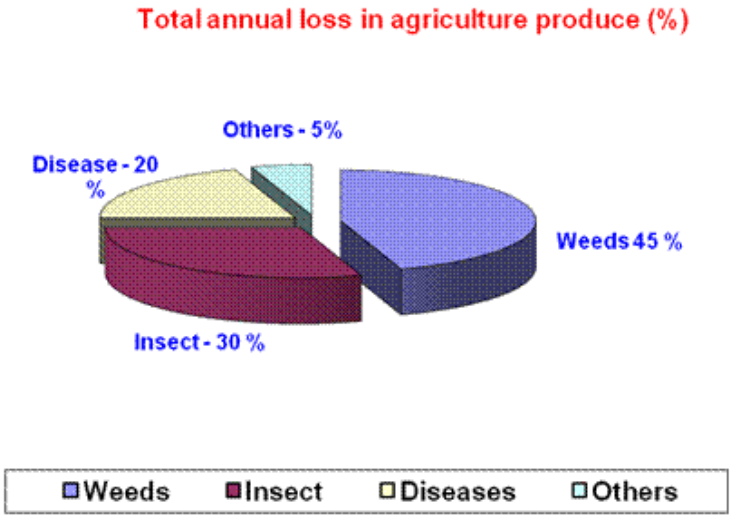


**Fig. 2: crop yield losses due to pest infestation**

**Challenges to adopt ZBNF:**

Natural farming is eco-friendly sustainable to the environment maintains good health of soil, plant as well as human beings by increasing beneficial microbial population, chemical-free nutrients supply to plants and toxic-free food supplies to consumers (man and animals). But still, farmers are not going to adapt this technology due to some lacunas so the govt, researchers, scientist and extension workers should think about major challenges to success this zero budget natural farming technology in

a large area, and according to authors view some of the major challenges are listed below.

1. the labor requirement is increased compared to conventional farming, and
2. The demand for animal manure is high. On a national scale, the number of cattle in India could not support this level of manure application.
3. With the demand and consumption pattern constantly changing when it comes to high-value products.
4. Better technology and high investment are required on farmland. Well developed heavy machinery, implements are not used in natural farming due to it creates soil compaction even there is no use of tractors in it.
5. Weakened agricultural market infrastructure- there is no value of natural products in large scale areas even the price also similar to chemically produced products.
6. No scientific validation- microbial composition, efficiency, and impact of jivamrith, bijamrith, bramhastra, dashaparni kashaya not yet tested and there is no scientific data on it.
7. Hybrid varieties, not permitted- continuously increasing global population food is scarce to all populations. Even by using chemicals, we are not reaching our food production target, without hybrids, it is impossible to reach the target.
8. Promotion of ZBNF on a large scale without scientific validation and under the political influence- no scientific data on crop yield.
9. Pest management is difficult- different crop-specific weeds, diseases, insects are damaging to crop drastically, by using natural products its control is not satisfactory to farmer's level.
10. Quality planting material and other proven techniques like GMO's are not considered in ZBNF
11. Criticizes other agroecological and organic farming techniques
12. Non-availability of indigenous cow, it contains Millions of beneficial microbes and pathogen-free dung
13. As ZBNF adapted in India by Mr. Subash Palekar is not adopted in his own state Maharashtra
14. Appropriate policy framework
15. Setting specific standards
16. Non-availability of commercial formulations- naturally formed growth stimulants, pest control *astras* are not available on large scale, and its storage life is less no longer keep this product and not available in local markets.
17. Development of a package of practices of all crops- there is no specific package of practices to crops grown under natural farming the state universities, govt. institutions and extension workers should concern about this.

**Opportunities to adopt ZBNF**

As concerning green revolution use of high yielding varieties, chemical fertilizers, and pesticides are reduces soil health by withdrawing high levels of nutrients from the soil, reducing the population of beneficial microbes and accumulation of toxic substances in the soil profile as well as pollutes groundwater. These all create a negative impact on the environment and human health. The main source of plant nutrients is organic matter due to the burning of crop residues, which reduces soil organic matter content creates more air pollution. Concerning this increasing globalization, there is a need for environmental sustainability, maintaining the environment to the future generation. Even farmers are facing high input costs in commercial farming even though they are not getting much profit in it. Natural farming gives better opportunities to solve these problems in a better manner.

1. Conserving nature- this practices 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 enhansing water quality and increase availability during extreme weather events.

2. Reduces health risks from chemicals-mentains 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. Most of the pesticides are consumed by fruits and vegetables and retained longer time in it, so natural farming avoids this problem.
3. Reduction in carbon emissions and carbon capture- one tonne of residues burning can produce 400 kg of carbon to the environment (Gupta, 2019) if the residues are surfaces retained or incorporated into soil that will supply carbon to the soil which helps to produce more yield. So the 5 lakh farmers having 202,500 hectares of land moving towards natural farming.
4. Social impact- due to low input, cultivation cost reduced and stable yields enable farmers to have consistent quantities of crops to sell in the market so their livelihoods are more secure.
5. Net economic impact- some papers noticed that every 1 USD invested on a farmer to adopt ZBNF results in direct benefits equalling 13 USD. The direct benefits are- reduced costs of cultivation, higher yield, lower costs of borrowing, gain income from intercrops, and a slightly higher selling price. 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.
6. 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. both The United Nations Environment Programme, BNP Paribas and the World Agroforestry Center (ICRAF) are work through the Sustainable India Finance Facility (SIFF) to work with the government of Andhra Pradesh to support the scale-out to 6 million farmers and as partners, some organization like e Azim Premji Philanthropic Initiatives (APPI), TEEB Agriculture Food study, FAO and Council on Energy, Environment and Water are participating. About ` 324 crores spent to popularise ZBNF among the farmers and proposed to extend from 6 to 9 mha area by 2022-24. And Andhra Pradesh moves to turn world 1st natural farming state was estimated cost 17,000 crores.

**Public policies need towards zero budget natural farming**

- The shift in public policy framework- As per Ramanjaneyulu scientist at the centre for sustainable agriculture, a shift to diversified, biological resource integrated models of agriculture is required to correct inappropriate resource use. Shift to intercropping, multiple cropping systems, appropriate crop rotations, and integration of crops and animals. Land use along with farming systems need to be planned consciously by paying attention to the challenges of ecological intensification. The shift in the support systems (prices, subsidies, research, institutions) should be reconfigured from current subsidies on external inputs to support ecosystem services. Maintaining ecosystem specific agronomic diversity is essential. For example, the wetlands, rainfed areas, hill regions, etc need support to practice appropriate farming systems. Centralized, monoculture based current unsustainable models of agriculture have to be stopped. Instead of same cropping system, go with safe food like millets, pulses, oilseeds, and various locally grown fruits and vegetables cultivation. Strictly follow the regulations and control the use of inappropriate technologies like agrochemicals, GMOs, and other technologies that have biosafety implications. The emerging crisis impacting pollinators and the consequent deleterious impact on the productivity and yields of several crops has to be recognized and dealt with utmost urgency. Appropriate

space for no formal knowledge systems has to be provided.

- Increase the right investments in agriculture- 10-15 % of union budgetary allocations to ZBNF. Increase more informed choices to farmers than driven by captive institutions. Support for farmers owns labor, resources, and knowledge. Support for Ecosystem Services.
- Ensuring income security- Farmers Income Commission should ensure statutory commission of balancing decisions affecting costs of Production, subsidies and support costs of living, and prices of produced products.
- Agricultural Research- Agricultural research needs to adopt an agroecological perspective while setting the research and training agenda. Researchers should shift towards participatory approaches involving practicing farmers and farm workers and develop appropriate technologies to suit their needs. Collective, location-specific approaches to extension have to be followed to restore the health of agro-ecosystems. Increased investments in agroecological research need to be made. Agricultural research performance should be redefined to include the criteria of sustainability and ecosystem health. Low volume and long shelf life of the bioproducts should be made.
- Work from the agricultural extension- Ideally block-level down should be converted into community managed extension, the shift from information-based to the knowledge-based system and use of experienced farmers as resource persons.
- Marketing support to farmers- develop state-level commodity board that can help to FPOs (farmers participatory organizations) with technical support, quality management, access to finances, and markets. The infrastructure supports in terms of storage/processing units.

## CONCLUSION

Zero budget farming is environmentally friendly. Savings on the cost of seeds, fertilizers, and plant protection chemicals have been substantial. Because of continuous retention of crop residues replenishment the soil fertility, it helps to maintain the soil health. Other thing is that management of pest and diseases is a key component in zero budget natural farming crop production systems. Successfully control pests in ZBNF, it is essential to understand the interactions of different components in a specific ecosystem. The new system of farming has free debt trap of farmers and it has instilled in them a renewed sense of confidence to make farming an economically viable venture. The challenges and opportunities are two parameters that show the systems lacunas to researchers, scientists, and extension workers and benefits to adopters, and policy intervention is necessary to make success.

## REFERENCES

Agoramoorthy, G. Can India meet the increasing food demand by 2020? *Futures 40*, 503-506 (2008).

Andow, D.A., & Hidaka, K. (1998). Yield loss in conventional and natural rice farming systems. *Agri Eco and Envi*., *74*, 137–155.

Ayansina, A.D.V., & Oso, B.A. (2006). Effect of two commonly used herbicides on soil microflora at two different concentrations. *African J Biotech 5*, 129-132.

Barabasz, W., Albińska, D., Jaśkowska, M., & Lipiec, J. (2002). Biological Effects of Mineral Nitrogen Fertilization on Soil Microorganisms. *Pol Jour of Envi Stu*., *11*, 193-198.

Bruinsma, J. (ed.) *World Agriculture: Towards 2015/2030. An FAO Perspective* (Earthscan, 2003).

Byrnes, B.H. (1990). Environmental effects of N fertilizer use- An overview. *Fert Res*., *26*, 209.

Chen, C., Bauske, E.M., Musson, G., & Rodríguez, K.R. (1995). Biological control of Fusarium wilt on cotton by use of endophytic bacteria *Biological Control*, *5*, 83-91.

Cobb, G.P., Sands, K., Waters, M., Wixson, B.G., & Dorward, K.E. (2000). Accumulation of heavy metals by vegetables grown in mine wastes. *Envi Toxi and Che*., *19*, 600-607.

Devarinti, S.R. (2016). Natural Farming: Eco-Friendly and Sustainable?. *Agro technology*, *5*(2), 1-3.

Doran, J.W., Sarrantonio, M., & Liebieg, M.A. (1996). Soil health and sustainability. Advance in Agronomy 56.

Fukuoka, M. (1978). The one straw revolution. Rodale Press, Emmaus, PA, USA.

GEF. (2019). Report of the Global Environment Facility to the Fourteenth Session of the Conference of the Parties to the United Nations Convention to Combat Desertification; https://go.nature.com/2tzvntM.

Glick, B.R., & Abd Bashan, Y. (1997). Genetic manipulation of plant growth-promoting bacteria to enhance biocontrol of phytopathogens. *Biotech Adv*., *15*, 353-378.

Glick, B.R. (1995). The enhancement of plant growth by free-living bacteria. *Can. J. Microbiol 41*, 109-117.

Gupta, N. (2019). Paddy Residue Burning in Punjab: Understanding Farmers' Perspectives and Rural Air Pollution, March.

Hough, R.L., Breward, N., Young, S.D., Crout, N.M.J., & Tye, A.M. (2004). Assessing potential risk of heavy metal exposure from consumption of home-produced vegetables by urban populations. *Envi HP*., *112*, 215-221.

Intawongse, M., & Dean, J.R. (2006). Uptake of heavy metals by vegetable plants grown on contaminated soil and their bioavailability in the human gastrointestinal tract. Food Additives and Contaminants. *23*, 36-48.

Jenkinson, DS. (1982.) The nitrogen cycle in long-term field experiments. *Phil Trans RScoi., 269*, 569.

Khadse, A., & Rosset, P.M. (2019). Zero budget natural farming in India-from inception to institutionalization. *Agroecol. Sust. Food., 43*, 848–871.

Lazarovits, G. (1997). Rhizobacteria for improvement of Plant Growth and Establishment. *HortScience*., *32*, 188-192.

Mattina, M.I., Berger, W.I., Musante, C., & White, J.C. (2003). Concurrent plant uptake of heavy metals and persistent organic pollutants from soil. *Envi Poll*., *124*, 375-378.

Neera, P., Katano, M., & Hasegawa T. (1992). Rice culture under Nature Farming in Japan. *Proc Fac Agric KyushuTokai Univ*., *2*, 67-74.

Palekar, S. (2014). http://www.palekarzerobudgetspiritual farming.org.

Palekar, S. (2016) Zero Budget Natural Farming. http://palekarzerobudgetspiritual farming.org

Shaikh, N.F., & Gachande, B.D. (2015). Effect of Organic Bio-Booster and Inorganic Inputs on Rhizosphere Mycoflora Population and Species Diversity of Wheat. *Int Jour of Sci and Res 4*, 295-302.

Singh, J.S., Pandey, V.C., & Singh, D.P. (2011). Efficient soil microorganisms: A new dimension for sustainable agriculture and environmental development. *Agri Eco Envi*., *140*, 339-353.

Smith, J., Yeluripati, J., Smith, P., & Nayak, DR. (2020). Potential yield challenges to scale-up of zero budget natural farming. *Nature sustainability*, Analysis: 1-6.

Sreenivasa, M.N., Naik, N.M., & Bhat, S.N. (2010). Beejamruth: A source for beneficial bacteria. *Karnataka J Agric Sci*., *17*, 72-77.

The Hindu (2019). Govt. should stop promoting zero budget natural farming pending proof: scientists. (11 September 2019); https://go.nature.com/2FrKSH1.

The Hindu. (2019). What is zero budget natural farming?.

The Hindu. 2019. Campaign to Reduce Use of Chemical Fertilizers, Pesticides. May 28. http://bit.ly/1tpq0rT.

Wolnik, K.A., Fricke, F.L., Capar, S.G., Braude, G.L., Meyer, M.W. (1983). Elements in major raw agricultural crops in the United States. Cadmium and lead in lettuce, peanuts, potatoes, soybeans, sweet corn, and wheat. *JAFC*., *31*, 1240-1244.

Worldometer, (2020). Elaboration of data by United Nations, Department of Economic and Social Affairs, Population Division (www.Worldometers.info).

Zero Budget Natural Farming http://apzbnf.in (RySS, Government of Andhra Pradesh, 2018).