POLICY PAPER 90

Zero Budget Natural Farming - A Myth or Reality?

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI

November 2019

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CITATION : NAAS 2019. Zero Budget Natural Farming - A Myth or Reality? Policy Paper No. 90, National Academy of Agricultural Sciences, New Delhi: 20pp.

Published by Dr Anil K. Bawa, Executive Director on behalf of
NATIONAL ACADEMY OF AGRICULTURAL SCIENCES
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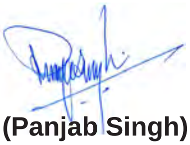
Preface

India is projected to become the most populous country in the world with a population of nearly 1.7 billion by 2050. In order to feed this population, the country has to adopt a policy of vertical growth in productivity as the opportunities of further horizontal expansion of cultivated area are almost exhausted. Also the continuous cropping depletes the soil nutrient reserves and hence, the soils are to be replenished with the essential major and minor plant nutrients. The nation cannot afford to compromise on the nutrient supply needed to overcome the “silent hunger” and the unethical perpetuation of high concentration of stunted and wasted children and anemic mothers. As of now there is hardly any scientific evidence to support detrimental effect of judicious use of fertilizers on soil health, crop productivity or farmers’ income. We need to promote farming systems and technologies which enhance income and also prove ecologically sound. While the country is in the process of planning to revamp its agricultural production system including R&D to meet the emerging challenges, the economic survey of 2018-19 made fervent appeal for adoption of ‘Zero Budget Natural Farming’ (ZBNF) in a big way to double farmers’ income, and it was subsequently endorsed by the Hon’ble Finance Minister while presenting the Union budget 2019-20 in the Parliament.

Realising the importance and the scientists' demand for discussion on the subject, the Academy organized a Brainstorming Session on August 21, 2019 inviting all stakeholders concerned with the subject including industries, policy planners and farmers. About 75 participants took part in a day long deliberation. After detailed discussion, a consolidated view emerged that before arriving at any conclusion on up-scaling or promoting any of these alternative technologies being proposed by different individuals or groups, it is important to undertake scientific evaluation of these technologies and their likely impact on food security of the country. There is no scope for an incremental value gained by the farmer or the consumer through ZBNF that represents one of the many such practices followed in India prior to the 1950s.

There have been a few reviews and opinions on ZBNF. All of them, however, conclude that the claims of ZBNF are questionable and need scientific validation. Studies on ZBNF initiated by the ICAR-Indian Institute of Farming System Research (IIFSR), Modipuram at several locations in the country and University of Agricultural Sciences (UAS), Dharwad have clearly indicated that yield levels were drastically reduced in several cropping systems. Therefore, it would be premature to recommend its wide-spread adoption which may lead to massive damage to the hard-earned knowledge and benefits of agricultural R&D over the last 70 years. The ZBNF cannot provide adequate quantity of nutrients required for higher crop productivity as soil has a limited nutrient supplying capacity. In addition, ZBNF recommends use of traditional varieties of crops having almost half the yield potential of modern high yielding varieties. Thus, the crop productivity will be maintained at a low level and with this level of productivity, the farmers will not be able to earn enough to double their income and be free from the debt. Also, at the country level, we will not become self reliant to meet the food and nutritional demand of the growing population and hence, will be failing in our task of meeting the Sustainable Development Goals (SDGs) of Zero Hunger and Poverty Elimination by 2030.

On behalf of the Academy, I compliment the Resource Persons Drs H.S. Gupta and C.L. Acharya along with other eminent experts for their valuable inputs in developing this Policy Paper. My thanks are also due to Drs V.K. Bhatia and Kusumakar Sharma for their editorial support. I am hopeful that this document will be useful to all Fellowship, policy makers and other stakeholders.



(Panjab Singh)
President, NAAS

Zero Budget Natural Farming - A Myth or Reality?

1. INTRODUCTION

Agriculture in India dates back to approximately 11,000 years during which the country witnessed numerous crests and troughs including famines, and the farmers had been mainly practicing natural/orgainic farming. This has undergone a sea change in the living memory. While the country imported 6-10 million tonnes (Mt) of wheat annually to feed 1/3rd of today's population (1.3 billion) during mid-1960s, the Green Revolution (GR) transformed the country to a state of self-sufficiency in early 1970s by adopting various modern methods and technology, which included the use of seeds of high yielding varieties, chemical fertilizers, irrigation facilities, pesticides and farm machinery, backed by increased public investment and facilitating institutions. Thereafter, the country never looked back and continued not only to produce enough to feed its ever growing population but also became a net exporter of several agricultural commodities, valued at ₹ 235,000 (two hundred and thirty five thousand) crores during 2017-18. This spectacular success was achieved with the hard work of Indian farmers supported by favorable policies of the government and continuous R&D backing by scientists. It would be relevant to mention here that during the last 70 years starting from 1950, our food production has increased by more than 5 times (from 50.8 Mt in 1950-51 to 284.8 Mt during the year 2017-18) whereas the population grew only 3.5 times. This incredible achievement was made possible mainly by increasing the productivity of food crops (*viz.* wheat, rice, and pulses) and partly by expanding the area (under these crops). It is worthwhile to mention here that the food production records have been broken year after year with the net cultivated area remaining 140 ± 2 million hectare (Mha) since the 1972. However, despite impressive gains in farm productivity, farmers' income remained low in comparison to those working in non-farm sectors. The liberalization of the Indian economy further led to an agrarian crisis that made small and marginal farms unviable. Meanwhile, many individuals working singly or in small groups around the world in different areas of human interest blamed the contemporary scientific agriculture responsible for environmental degradation, climate change, loss of biodiversity and persistent poverty, although it is completely incorrect. These groups advocated 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. In the meantime, realizing the declining total factor productivity and profitability of the farmers in general, and small and marginal farmers in particular, the Government of India, particularly *NITI Ayog,* has been looking for alternative farming systems that could be more profitable with reduced input and cost. And there came a few alternative farming methods like *Vedic Farming, Agnihotra Farming, Amrutpani Farming, Homoeo Farming and Zero Budget Natural (Spiritual) Farming* claiming exciting but scientifically unproven results. One of these farming methods being spread rather aggressively in the States of Maharashtra, Karnataka and Andhra Pradesh is the 'Zero Budget Natural Farming (ZBNF), which has recently been endorsed by the Government of India too. Nevertheless, before arriving at a conclusion regarding upscaling, out-scaling or promoting any of these alternative technologies, it is important to undertake their scientific evaluation and likely impact on food security of the country. Furthermore, it would be appropriate to examine the various methods of agricultural production used in the past (ancient, medieval and modern periods) in different parts of the country *vis-a-vis* the status of food production, level of productivity and sustainability thereof to arrive at a conclusion about their efficiency. Keeping these objectives in view, the National Academy of Agricultural Sciences organized a brainstorming meet on August 21, 2019 where various issues and approaches including ZBNF were deliberated upon and science-based recommendations were made.

2. AGRICULTURE IN PRE-INDEPENDENT INDIA

Records of cultivation of rice, wheat, millets and pulses as food crops in ancient as well as medieval India (Randhawa, 1980) show that ancient India was not only self-sufficient in food but exported a wide range of agricultural produces like spices, rice and cotton & silk textiles. The self- sufficiency (in food) was mainly due to low population (~100-125 million during 1600 AD). Estimates made by several historians show that though India was thickly populated; yet, its population growth was only marginal for around 2,000 years from 300 BC to 1600 AD (Davis, 1951). Agro-climatic conditions and soil fertility, however, enabled harvesting of two crops in a year which helped in ample production of food grains during that period. The medieval period (particularly the Post-Akbar), however, started experiencing decline in agricultural production, which caused reduction in availability of food, ultimately resulting in several famines, *viz.* the great famine of Madras in 1647, and that of Gujarat in 1666 quickly followed by two more famines (in Gujarat) in the years 1718 and 1744 (Randhawa, 1982). The problem was compounded with the advent of British rule during which the emphasis shifted to production of commercial crops like tea, coffee, indigo, opium, jute, cotton and sugarcane (Bayly, 1985) that resulted in reduced emphasis on food crops; for example, from 1901 to 1947, the food production declined - whereas the population rose by 38%, the increase in cultivated area was to the extent of 18% only. The crisis was most acute in Bengal, where food output declined at an annual rate of 0.7% from 1921 to 1946, whereas population grew at an annual rate of 1% (Kumar, 2019). There were some efforts though by the British rulers to expand irrigation in the form of wells or canals (Randhawa, 1983); even then the total annual production of food grains remained far below the requirement to feed the nation. Various reports mention loss of approximately 60 million lives in several famines in pre-independent India, and the country was branded as a 'Hungry Nation' (Siegel, 2018). The recurrence of famines opened the eyes of British rulers and the then British Government decided to establish six agricultural colleges/research institutions during the fag end of 19th century and early 20th century. This was followed by a new impulse to develop agriculture (in India) by the appointment of 'The Royal Commission on Agriculture' in the year 1926 which recommended the creation of Imperial Council of Agricultural Research to promote, guide, and co-ordinate agricultural research throughout India and the same was set up on May 23, 1929.

3. AGRICULTURE IN INDEPENDENT INDIA

With the dawn of Independence in August 1947, the country started making systematic efforts in improving agriculture and R&D to develop new technologies that would make the country self-sufficient in food which was the prime need of the nation at that point of time. Agriculture was indeed accorded top priority which was reflected in the statement "Everything can wait but not agriculture" attributed to the first Prime Minister of Independent India.

3.1 Pre-Green Revolution Period

At the time of Independence, agriculture in India was passing through a very difficult phase regarding availability of food. Bengal had just passed through a major famine of 1943 (Siegel, 2018). Per capita availability of food grains per day was far below the subsistence requirement and it was indeed a matter of great concern. In order to meet the domestic requirement, food grains had to be imported and the quantity of import steadily rose from 1.5 Mt in 1946 to 4.8 Mt in 1950 peaking at 10.4 Mt in 1966. The first step that the then government took was in improving irrigation facilities, which had been severely depleted with the partition and only 19.7% of the net sown area, in the Indian Union, was irrigated. As a result of concerted efforts of the Government of India, the net irrigated area increased to 20.2 Mha during 1949-50; most of the increase came from expansion in the area irrigated by wells and other minor sources. Though the slow expansion of irrigation and various land reform measures were leading to a sustained rise in agricultural production, yet this increase in production was just not reaching the markets and therefore, the urban population had to be fed with increasing imports till the mid-1960s. Further, the agricultural production in the 1950s and early 1960s was by and large independent of inputs from outside the agricultural sector. The National Commission on Agriculture noticed that the production depended largely on the amount of labour the cultivator was able or prepared to put in. All inputs were farm produced (NCA, 1976). This was a situation where not only the average per capita availability of food was low but also a large proportion of rural population, nearly 40% in 1960-61, did not have sufficient purchasing power to buy the bare minimum quantity of food to supply 2,250 calories per day. The situation worsened further in the drought of 1965 when adequate food availability became a problem and in some states like Bihar, famine-like situation prevailed (Siegel, 2018). The situation was, however, managed with the efforts of various agencies of the state governments, federal government and several non-government organizations from within the country as well as from overseas. It would not be out of place to mention here that the country produced only 72.3 Mt of food grains in 1965-66, 10 Mt less than what was produced in 1960-61, and India had to import 10.4 Mt of wheat during 1966 under PL-480 to feed the growing population. The then Prime Minister of India, Shri Lal Bahadur Shastri had gone to the extent of giving a call to the citizens to skip one meal once every week.

3.2 Green Revolution Era

The planners were in search of an agricultural technology that would bring about a transformative change in agricultural production and no such technology was available at that time. The research work was, however, on (since 1961) to test the dwarf wheat received from Dr Norman Borlaug working at CIMMYT and two dwarf lines of wheat were released in the year 1965. These dwarf varieties of wheat were selected to respond to higher doses of chemical fertilizers without lodging but were susceptible to a number of pests and needed to be grown under the protective cover of pesticides. The new seeds also required new sophisticated practices for irrigation, tillage, *etc.* This was thought to be an ideal technology under the prevailing situation at that time. However, there was a snag. Acceptance of this technology would involve import of large quantities of fertilizer and pesticides, as India did not produce these. In the initial stages, even the seeds would have to be imported. Further, there was a widespread failure of monsoon in 1965 and 1966 in India, as well as over the rest of South Asia and South East Asia. This situation removed all hesitation about accepting the new seeds even if they involved massive imports. And India imported 18,000 tonnes of the seeds of the dwarf varieties of wheat in the year 1966 and the same were distributed in wheat growing areas of the country especially in Punjab. The country which produced 10.4 Mt of wheat in 1965-66 (and imported ~10 Mt of wheat under PL 480 to feed the nation), produced 18.6 Mt in 1968-69 and 23.8 Mt in 1970-71 thus stopping wheat import. Likewise, around the same time a dwarf variety of rice, IR 8 released by IRRI in 1966, was tested and popularized in India and rice production jumped from 30.4 Mt in 1966-67 to 42.2 Mt in 1970 -71. Thus making the country self-sufficient in food grains. Similar programs were adopted in all of South and South East Asia at around the same time. The program was declared an immediate success (Cullather, 2010) and came to be known as ‘Green Revolution’ (GR).

3.3 Post-Green Revolution Period

The new technology of the ‘miracle seeds’ and associated practices was indeed successful in generating high yields, wherever sufficient resources to effectively implement them could be mobilized. For some especially endowed areas, the increase in yield could even be justifiably characterized as revolutionary. This was amply borne out by a number of studies carried out to make a scientific evaluation of the response of different crops in different areas under the High Yielding Varieties (HYV) Program. Thus, the prophecy of William and Paul Paddock in 1967 who predicted doom in their famous book ‘Famine 1975!’ and even the possibility of millions of starvation deaths were proved wrong. The success was rated as one of the most important achievements of Independent India as hailed by the then President of India during special mid-night session of Parliament to celebrate Golden Jubilee of India's Independence in the year 1997. It is pertinent to mention here that during the year 1950-51, India produced only 50.8 Mt of food grains, 25 Mt of vegetables and fruits, 17 Mt of milk, 1.8 billion eggs and 0.75 Mt of fish. And these figures for the year 2017-18 are 284.8 Mt of food grains, 281.8 Mt of vegetables and fruits, 164 Mt of milk, 87 billion eggs and 13.8 Mt of fish. The increase in production of food grains was 5.6 fold; vegetables and fruits 11.3 fold; eggs >100 fold; milk 9.6 fold and fish 14.4 fold since 1950-51. These are the glaring examples of technology-driven growth of agriculture in India. In fact, Green Revolution was in itself an innovation-led initiative around the use of high yielding dwarf wheat and rice varieties that responded favorably to higher inputs leading to quantum jump in productivity.

The other two factors that had helped ushering in the Green Revolution, were the use of chemical fertilizers and expansion of irrigation. The Indian scenario clearly demonstrates the relationship between food production and consumption of total plant nutrients (NPK). The gross food production, although, is the integrated effect of all the factors but the linear relationship between NPK use and food production is unmistakable. While the fertilizer consumption increased from a small amount of < 1 kg nutrient per hectare in 1951-52 to 74 kg/ha in 1995-96 to 131.6 kg/ha in 2014-15 to 137.4 kg/ha in 2018-19, the gross irrigated area increased from 22.6 Mha in the year 1951-52 to 96.5 Mha in the year 2014-15. The high yielding varieties although catalyzed holistic effect of seed, fertilizers, irrigation & management and accordingly, the nutrient (NPK) consumption increased to about 26.7 Mt in the year 2017-18 (Fertilizer Statistics FAI, 2018-19) from a mere 65.6 thousand tons in the year 1951-52; it is still not adequate to realize the full potential of the available agronomic technology. The estimates for the year 2025 show (Kanwar and Katyal, 1997) that India may need nearly 45 Mt of plant nutrients, of which at least 35 Mt will come from the chemical fertilizers and 10 Mt from farmyard manure, other organic sources and biofertilizers. It is not one or the other but both are needed, otherwise the maximum potential of HYVs, soil and water cannot be realized. The adoption of efficient soil and water management practices, input of more organics and biofertilizers to increase the nutrient use efficiency by reducing the loss of nutrients is likely to reduce the requirement of chemical fertilizers and improve the economics of crop cultivation as well.

Dr Norman Borlaug had pointed out way back in 1994 that had India and China not used the plant nutrients at the level they were using, both would have required 2-3 times land area under cereals to produce the food grain in 1992 (China, 400 Mt; India, 200 Mt) as compared to 1960 (China, 147 Mt; India, 87 Mt). The land sparing effect of fertilizer is of much significance especially in land short countries like India to save grass and forest lands.

Another dimension of agricultural growth in post-GR period is whether the GR technology is capable of supporting the future requirement of food or is there a 'Technology Fatigue' or 'Yield Fatigue', as some people like to call, that has set in? This has been deliberated extensively with conflicting opinions; however, it can be explained by comparing the yield gain during pre-GR, GR and post-GR periods and such an analysis of agricultural growth has been published recently by Yadav *et.al.,* (2019) who divided the period between 1950 and 2017 in 4 phases - Phase-I (pre-GR era from 1950 to 1966); Phase-II (GR era from 1967 to 1983); Phase-III (post-GR-1 from 1984 to 2000) and Phase-IV (post-GR-2 from 2000 to 2017). They have clearly shown that the annual rate of gain in productivity (kg/ha/yr) of wheat in Phase III was 53.1 kg/ha, which is 30% higher than that of the GR era (41.0 kg/ha). Likewise, in rice, the productivity gain increased from 32.3 kg/ha in Phase-III to 41.6 kg/ha in Phase IV and these were 68% and 117% higher respectively than that in GR era (19.2 kg/ha). Furthermore, the rate of gain in productivity of maize and pearl millet in Phase-III and Phase-IV was 188 - 530% higher as compared to the annual growth rate during GR phase. This remarkable progress can safely be attributed to the technology-driven growth mediated by the development and adoption of improved varieties/hybrids and crop management technology.

The productivity gains, during the last 70 years that was directly translated in vertical growth in increased productivity per ha, were technology-driven and if we dispense with the continuous pursuit of newer technology, it may actually become difficult to meet the growing demand of food grains.

4. CURRENT CHALLENGES AND OPPORTUNITIES

The Green Revolution technology indeed brought about transformative changes in food production scenario of the country but it has also thrown new challenges before the nation. The major second generation challenges are declining factor productivity, inadequate and imbalanced use of nutrients especially of N, low water and nutrient use efficiency, depleting natural resources, scarcity of safe water for irrigation, increasing cost of inputs, higher incidence of diseases and pests, rising concern of nutritional quality and safety of food combined with adverse impact of climate change. Increasing income, especially of 80% farmers who are small and marginal, having holdings less than 2 ha, would require technologies and innovations by which they can save cost on inputs and have more income by way of higher productivity, quality product and linking to value chain and markets.

The decline in total factor productivity needs to be critically examined as it is linked to the consumption of chemical fertilizers *vis-à-vis* increasing crop productivity, cost of production, health of soil and environment. The fact that fertilizer was the key input in augmenting food grain production after the contribution of high yielding crop varieties, is evident from the increase in fertilizer ($N+P_2O_5+K_2O$) consumption from 1.98 Mt in 1969-70 to 18.07 Mt by 1999-00. Nevertheless, the average annual increase in fertilizer consumption witnessed a declining trend in these three decades, as reflected by 16.5% during 1970s, 12.04% during 1980s and 5.6% during 1990s. A simple regression analysis between the food production and fertilizer consumption during 1960-61 to 1999-00 shows that the partial factor productivity of fertilizers has been continuously declining, especially when balanced fertilizer application is not practiced. This is supported by the fact that the farmers in the rice-wheat belt (especially Punjab, Haryana and western U.P.) are forced to apply more and more chemical fertilizer to obtain the same crop yields as in the preceding years. The fertilizer response ratio (kg grain per kg nutrient) decreased by nearly four times (from 13.4 in 1970 to around 3.2 in 2010) in irrigated areas of the country. This ratio has further declined to 2.8 in recent years (Chaudhari *et. al.,* 2015).

Our soils are not only low in soil fertility but there is inadequate and imbalanced nutrient use. The current gap between annual drain of nutrients from the soil and inputs from external sources is about 10 Mt, which is likely to grow further. The excessive removal of native nutrients from the soil is one of the major causes resulting in poor soil health. However, on the input side, there is large disparity in fertilizer consumption across Indian states and lack of assured water supply for irrigation is one of the major reasons for low fertilizer input, as for example, only 120 districts in the country consume fertilizer NPK > 200 kg/ha. In Punjab, where more than 98% of the area is irrigated, 12 out of 20 districts surveyed consume fertilizer NPK > 200 kg/ha, 7 districts fall in the category of 150-200 kg/ha and only 1 district falls in the category of 100-150 kg/ha. Thus, Indian agriculture is operating as a net negative balance of plant nutrients resulting in chemical degradation and poor soil health. Furthermore, the soils are also getting continuously depleted of secondary plant nutrients and micronutrients. It is pertinent to mention that the micronutrient deficiency in Indian soil is in the order of 36, 44, 23, 13, 8 and 4% for Zn, S, B, Fe, Mn and Cu respectively (Shukla *et. al.,* 2018). The limiting nutrients do not allow full expression of other nutrients on one hand and lower the fertilizer response as well as crop productivity on the other. Although, fertilizer consumption has been increasing at a fast rate since 1970s, the yield response to fertilizer is declining at a similar pace. Poor soil health results in low nutrient use efficiency. There have been genuine concerns over fertilizer use efficiency, in general, and N use efficiency (NUE) in particular, for economic as well as environmental reasons. Worldwide, NUE for cereal production (wheat, rice, maize, barley, sorghum, millet, oat and rye) is as low as 33%. The unaccounted 67% represents an annual loss of N fertilizer worth up to ₹ 72,000 crores in monetary terms (NAAS, 2005) and this can be reduced to a great extent by making application of organics (FYM/compost) mandatory in combination with recommended dose of chemical fertilizers.

In India, though about 70% of fertilizer used consists of nitrogenous fertilizers and 80 per cent of it is urea, its use efficiency is hardly 30-50 per cent (NAAS, 2018). The fertilizer use efficiency in case of other nutrient elements is 15-20% for P, 60-70% for K, 8-10% for S and 1-5% for micronutrients which is a major cause of concern. Opportunities, however, exist to address these challenges through integrated use of organic manures and inorganic fertilizers, development and use of novel fertilizer products, micro-irrigation, and conservation and precision agriculture, where we can reduce the input of chemical fertilizers, arrest the decline in factor productivity and increase the input use efficiency of water and applied nutrients without sacrificing crop yields. While these challenges are being addressed in the most scientific manner, many individuals and some groups have come up with alternatives to scientifically proven modern technologies, which are, however, not based on any scientific evidence to support higher crop productivity and sustainability. Zero Budget Natural Farming (ZBNF) is one of them that has lately gained substantial popularity among different stakeholders and thus merits attention of the scientific community.

5. ZERO BUDGET NATURAL FARMING (ZBNF)

ZBNF is based on 4 pillars *viz.* (i) *Jeevamrit*- nectar of life (consisting of microbes) that is prepared from dung and urine of indigenous Kapila cow (not other animals like exotic or cross-bred cows, bulls or buffaloes), (ii) *Beejamrit*- the seed treatment, (iii) *Acchadana* (mulching) and (iv) *Waaphasa* (soil aeration/ moisture). Plant protection measures include a mixture of butter milk, cow milk, pepper powder, neem seed and green chilli (Palekar, 2016). Thus, ZBNF is low-input, climate-resilient type of farming that encourages farmers to use low cost locally-sourced inputs, eliminating the use of chemical fertilizers and industrial pesticides. The word 'budget' refers to credit and expenses, thus the phrase 'Zero Budget' means without using any credit, and without spending any money on purchased inputs. Natural farming means farming with Nature and without chemicals. It is presumed that it encourages the natural symbiosis of soil microflora and crop plants. It is, thus, expected to have no or least side effects on the health of soil and environment. ZBNF promises to end a reliance on loans and drastically cut production costs, ending the debt cycle for desperate farmers.

More importantly, the proponents of ZBNF ban the use of modern varieties with high yield potential and recommend the use of only traditional varieties/land races with inherently low yield potential. This is an obvious recognition that the traditional varieties respond to low level of soil-bound nutrients and in case higher quantity of nutrients are made available they tend to lodge resulting in poor translocation of nutrients that ultimately causes yield reduction. By contrast, one of the most important components of India's success in transforming its agriculture is the development and spread of high yielding modern varieties in almost every crop that have more than doubled the yield potential as compared to that of traditional varieties of crops like rice, wheat, maize, millets, pulses as well as oilseeds and the country has already reaped and will continue to reap the potential of these high yielding modern varieties in future. It's important to mention here that the seed treatment of traditional varieties with so called Beejamrit of ZBNF will in no way increase the yield potential of these varieties and the maximum it can do is to protect the Beejamrit -treated varieties from some diseases and the microbes can add a few plant growth promoting substances which can have incremental effect and will definitely not impart quantum jump in their yield.

ZBNF has recently been re-christened as 'Subhash Palekar Natural Farming' (SPNF) after the name of its prime mover, Mr Subhash Palekar, who taught this new method of farming to the farmers in his 1st workshop that was organized at Wayanad in Kerala in the year 2008 (http://palekarzerobudgetspiritualfarming.org). But the system is supposed to have existed since mid 1990s in southern India, notably in the state of Karnataka. Later, it was promoted by the Government of Andhra Pradesh during the last two decades as 'Community Managed Sustainable Agriculture' (CMSA) or 'Climate Resilient Zero Budget Natural Farming' (CRZBNF). The Government of Andhra Pradesh spent about ₹ 324 crores to popularize it among the farmers and proposed to extend it to six million farmers of the state cultivating 9 Mha area by 2022-24 in a phased manner. The move to turn Andhra Pradesh into world's 1st natural farming state was estimated to cost ₹ 17,000 crores (equivalent to 2.3 billion US $) and was proposed to be raised as loan based on state guarantee. 'Azim Premji Philanthropic Initiative' has already extended a ₹ 100 crore grant for this purpose. Apart from this, attempts are being made to promote this new method of farming in a big way by non-government organizations as well as governmental agencies as presented below:

5.1 Endorsement by the Government of India

While the country has been planning to revamp its agricultural production system including R&D to meet the formidable challenges being faced by it, the economic survey of 2018-19 made a fervent appeal for the adoption of 'Zero Budget Natural Farming' (ZBNF) in a big way to double farmers' income and it was subsequently endorsed by the Hon'ble Finance Minister during her budget speech in the parliament. ZBNF is said to be 'Zero Cost or Zero Input Natural Farming' and, therefore, whatever quantity is harvested is treated as net profit to the farmer.

5.2 Need for Scientific Validation

There have been a few reviews and opinions on ZBNF (Munster, 2018; Agarwal, 2019; Ramakumar and Arjun, 2019 and an editorial in 'Economic and Political Weekly' entitled ‘Mirage of Zero Budget Farming’ in July 27, 2019 issue). One of the leading journalists, Mr Vivian Fernandes recently visited Palekar’s farm and interacted with the representative of Mr Palekar at his farm as well as farmers near Palekar’s farm. The article “Does Zero Budget Natural Farming Work? A Reality Check” appeared in 15th July 2019 edition of the ‘Quint’. All the above mentioned articles conclude that the claims of ZBNF are questionable and need further scientific validation. In fact, a considerable number of farmers in Maharashtra have shifted to chemical nutrient-based farming (Bhosale, 2019)

ZBNF has, however, aroused a great deal of interest among the farmers as well as funding agencies including a few State Governments. Now, even the Federal Government has endorsed it for large scale adoption. One of the ICAR’s institutes, the Indian Institute of Farming Systems Research (ICAR-IIFSR), Modipuram has initiated work on its scientific validity. A committee headed by the Vice Chancellor of Professor Jaishankar Telangana State Agricultural University, Hyderabad, is examining the results of these multilocation trials. It is well-established that technology is the driver of growth and the spirit of science demands that this new system of farming, in which huge resources are proposed to be invested, should be examined/evaluated scientifically.

It is, therefore, premature to recommend its wide-spread adoption which may lead to massive damage to the hard-earned knowledge and benefits of agricultural R&D over the last 70 years.

6. FEEDING WORLD’S LARGEST POPULATION IN 2025 & BEYOND

India will soon become the most populous country in the world with an anticipated population of nearly 1.7 billion by 2050. In order to feed this population, the country has to adopt a policy of vertical growth in productivity as the chances of horizontal expansion in cultivated area are almost impossible. An assessment of projected requirement and ways & means to produce adequate quantity is presented below:

6.1 Projected Demand of Food & Nutrition

If India is to attain and maintain a GDP growth rate of 8.0%, then we need to produce 457 Mt of food grains (including 50.3 Mt of pulses) by 2050. Similar increase in production level of other food items like edible oils (45.2 Mt), vegetables (438.6 Mt), fruits (183.4 Mt), milk (483.6 Mt), sugar (58.2 Mt), meat (18.1 Mt), eggs (202.5 billions) and fish (27.0 Mt) is also required (Chand, 2012). This would require a four-fold increase in land productivity, a three-fold increase in water productivity, doubling of energy use efficiency- about half through labour & capital substitution and a six- fold increase in labour productivity

(Chand, 2012). Assuming that ZBNF is adopted by half of the small and marginal farmers who constitute 86% of the total farmers in the country, what would be the likely impact on the food production? In order to answer this, we need to address the following questions:

(i). Is it possible to meet the nutrient requirements of crops or will indigenous nutrient supply (even with microbial augmentation as suggested in ZBNF) suffice crop demand?

(ii). Can we produce enough and sustain the crop yields over the years to feed the growing population with ZBNF?

(iii) Are there adequate scientific evidences to support the advantage of ZBNF over scientifically proven crop management practices?

(iv). Does NARES consider ZBNF as a currently sound and relevant technology for reasonable scientific pursuit as given in the following site;

http://www.palekarzerobudgetspiritualfarming.org/zbnf.aspx

(v). Do we want to take agriculture in India away from evidence-based Science & Technology?

(vi). Will reliance on ZBNF aid farmers to double their income and end the debt cycle?

(vii). Is the food produced by ZBNF superior in quality?

(viii). Should the Government of India invest in ZBNF in the absence of scientific and authenticable evidences?

Most of these questions have been briefly addressed either together (to avoid repetition) or separately in the subsequent paragraphs with scientific evidences.

6.2. Can ZBNF Meet the Nutrient Demand of the Crops?

Continuous raising of crops exhausts soil nutrient reserves and hence, soils have to be replenished with essential major plant nutrients. Later, the deficiency of secondary and micronutrients also emerges which may become a yield limiting factor and this deficiency also needs to be eliminated. For example, in rice-wheat system with 10 t/ha productivity, the total uptake of N, P_2O_5, K_2O is 225, 100 and 315 kg (Tandon, 2004). This requirement cannot be fulfilled without the application of chemical fertilizers if higher productivity levels are to be maintained. In addition to NPK, the 10 t/ha productivity of R-W system also removes about 40, 62 and 38 kg of S, Ca and Mg, respectively along with substantial amounts of micronutrients. Continuous cropping without adequate replenishment of nutrients obviously depletes soil's native reserves and affects its health. In that sense, it is essential to monitor the soil nutrient status through soil testing at regular intervals and recommend balanced fertilization as per the requirement of the crop to maintain the soil health for sustaining higher productivity levels. Further, the nutrient requirement can also be supplemented with addition of organics and bio-fertilizers which reduces the input of nutrients through chemical fertilizers and also enhances biological activity and physical health of soil that, in turn, increases the nutrient and water use efficiency while maintaining and sustaining the productivity at higher levels over the years. ZBNF, however, cannot provide this much quantity of nutrients as soil has a limited nutrient supplying capacity and hence, the crop productivity will be maintained at a low level.

With this low level of productivity (in ZBNF), the farmers will not be able to earn enough to double their income and be free from the debt. Also, at the country level we will not be able to meet the food and nutritional demand of the growing population and hence, will be failing in our task of meeting the Sustainable Development Goals (SDGs) of Zero Hunger and poverty elimination by 2030.

6.3. Crop Productivity and Yield Sustainability

Studies initiated by the ICAR-Indian Institute of Farming System Research (IIFSR), Modipuram at several locations in the country have clearly indicated that yield levels were drastically reduced in rice-wheat cropping system (the backbone of national food security) by 59% in wheat and 32% in basmati rice. Results of a three-year Natural Farming Experiment by the University of Agricultural Sciences (UAS), Dharwad indicated a yield decline of at least 30% in soybean-wheat, groundnut-sorghum and maize-chickpea cropping systems while it was 17% in cotton-groundnut inter-cropping system. These trials have clearly established that food security will be seriously challenged along with the farmers' income, if ZBNF is adopted.

The land and water resources are limited and there is a very remote possibility of bringing any additional area under cultivation considering the pressing demands of the industrial and urban sectors. The fact that the net cultivated area has remained more and less static for the last five decades, enhancing productivity (of the agricultural production system) by using all modern technologies is the only solution for ensuring food and nutrition security to the huge population with very diverse requirements.

It is not the fertilizer use but the inadequate and imbalanced use of fertilizer which is damaging soil health and should be a matter of concern to all including researchers, environmentalists, administrators and policy makers. Nutrients are to be applied on soil-test basis as per crop requirement. ICAR-AICRP (All India Coordinated Research Project) on Long Term Fertilizer Experiments (LTFE) continuing for the last 50 years in different agro-eco regions and cropping systems of the country, have proved beyond doubt the significance of balanced fertilization (Singh and Wanjari, 2017). Following are the results of significance:

i) Application of organics like FYM to the extent of 10-15 t/ha to a single crop in the cropping sequence along with recommended dose of NPK produced higher grain yields over the years in both crops at all centers in the country.

ii) The treatment with optimal NPK (100% of recommended dose) maintained similar yield trend as the NPK+ FYM for most of the years at most of the centres, but lately it showed declining yield trend unlike the NPK+ FYM.

iii) The decline in yield in 100% NPK in some centres was owing to deficiency of secondary and micronutrients like Zn, S, K, Ca and many other micronutrients which became evident after different number of years, depending upon the nature of soil, climate and management. This deficiency was, however, eliminated with the application of these micronutrients in 100% NPK recommended dose which restored the high yield trend, thus highlighting the significance of integrated nutrient management (INM) with combined application of organic and inorganic fertilizers for higher and sustainable crop yields.

In addition, organics with recommended dose of NPK not only produced and sustained higher crop yields but also showed improvement in all physical, chemical and biological attributes of soil health. This is evident from the build-up of soil organic carbon (SOC) content, an index of good soil health, at all the centres in the country. Thus, it is clear that there is hardly any scientific evidence to support detrimental effect of judicious use of fertilizers on soil health, crop productivity or farmers' income. It is also appropriate to mention here that despite application of 10-15 t/ha/yr of FYM for over 4 decades, SOC did not double whereas some supporters of ZBNF assure doubling of SOC in 1-2 years only. Apart from this, ZBNF also claims that dung and urine from one indigenous cow can support 30 acres (12 ha) of land. It is pertinent to mention here that one cow will be able to give around 5,000 kg dung in a year that will supply 12 kg N. The important question is: Can 12 kg N in combination with so called *Jeevamrit* and *Beejamrit* support cultivation of 12 ha (30 acre) of agricultural land?

6.4. Are there Adequate Scientific Evidences to Support Advantage of ZBNF over Scientifically Proven Crop Management Practices?

Although the work on ZBNF has been taken up by some states but no systematic data have been generated so far to prove the superiority of this technology over the scientifically proven crop management practices. However, the proponents of ZBNF continue to defend the technology without any scientific evidence (Palekar, 2019). This is intriguing and needs further discussion to clear the air around ZBNF.

6.5 Quality of the Produce

Increasing consciousness about conservation of environment as well as of health hazards caused by agrochemicals has brought a major shift in consumer preference towards food quality and safety, particularly in the developed countries. If Good Agricultural Practices (GAP) are strictly adhered to, safe & nutritious food could be produced by conventional integrated nutrient and pest management practices. It is a known fact that plants take nutrients in inorganic form only, even if we apply them through organic manure. As regards the claim (by the proponents of ZBNF) of superior quality of the produce under ZBNF, the produce of ZBNF will definitely be free from pesticide residue, but the farmers practicing ZBNF did not get premium price for their produce and thus the expectation of higher price for ZBNF produce has been belied resulting in their return to conventional farming practices using need-based chemical fertilizers.

7. STRATEGIES FOR MEETING THE FUTURE DEMAND OF FOOD

The country has to adopt a number of strategies to meet the future demand of food and nutrition of the growing population. This includes bridging yield gaps between yield potential and the yield levels achieved at the farm in major crops. Apart from this, increasing total factor productivity, judicious use of nutrients especially of chemical fertilizers & pesticides, efficient management of natural resources like soil and water, establishing value chain and market linkages to retain the interest of farmers in farming and attracting the youth in farming, is the need of the hour. Prevention/drastic reduction in post-harvest losses, processing and product development, integrated crop and pest management, adopting climate smart agricultural practices to avoid adverse impact of climate change on agriculture, giving special attention to developing technology for rain-fed areas, water harvesting, increasing water use efficiency, conservation agriculture, precision farming, empowering individuals, especially women in agriculture, food fortification and biofortification would ensure nutritional security. In order to overcome the widespread micronutrient deficiency in soil, application of compost has to be made mandatory along with application of balanced dose of chemical fertilizers. The Government needs to evolve a strategy to incentivize production and application of quality compost from cow dung in combination with huge crop residue produced in the country. In addition, massive urban waste should also be utilized and incentivized for producing quality compost.

8. THE WAY FORWARD

From the foregoing discussion, it is amply clear that ZBNF is a myth and not a reality as it is not supported by any science-led information. In the pre-independence period, the country had been following this type of farming and had faced many famines resulting in loss of life due to hunger and starvation. In the pre-green revolution period, India was importing food grains to feed the nation and inspite of all efforts of the Government of India including that of the foreign agencies like Ford Foundation and the Rockefeller Foundation; the yield levels remained low at 1.33 t/ha for rice and 1.35 t/ha for wheat under IADP and

IAAP initiatives (Siegel, 2018). These yield levels were without the addition of any market purchased inputs and the situation was almost akin to ZBNF.

The country has moved forward from a ‘ship-to-mouth’ economy to an economy where we are not only producing enough but also have become one of the major exporters of food grains and other agricultural products. This has largely been due to synergy of technologies, appropriate policies, services, farmers’ enthusiasm and strong political will. This situation is not to be reversed but further improved and strengthened to feed the growing population with challenges of yield sustainability, water scarcity, limited land availability, degradation of soil and water resources, higher incidence of diseases and pests, increasing cost of inputs, and above all the adverse impact of climate change. We should also not forget that nearly 1/4th of the world’s hungry and 40% of the world’s undernourished, stunted, and wasted children have their homes in India. Also, increasing income, especially of 80% of small and marginal and resource-poor farmers is a big challenge. This would require application of low cost, location specific and scientifically proven technologies to double their income. These farmers can be empowered by giving access to modern technologies of crop production. Denial, otherwise, may lead to a massive damage to the hard-earned knowledge and benefits of agricultural R&D over the last 70 years. Here, it is worthwhile to quote Dr Norman E. Borlaug, the Nobel laureate, who said, while delivering a keynote address at the 15th World Congress of Soil Science, at Acapulco, Mexico in 1994:

“For those of us on food production front, let us all remember that World peace will not be built on empty stomachs and human misery. Deny the small-scale, resource-poor farmers of the developing world access to modern factors of production – such as improved varieties, fertilizers and crop protection chemicals – and the world will be doomed – not from poisoning, as some say, but from starvation and social and political chaos”.

Thus, condemning the technology that ushered in Green Revolution for the negative impacts on the environment and health is neither fair nor justified. It was the injudicious, indiscriminate and excessive use of agro-chemicals which is to be blamed. There was and is a need even today for the extension personnel to convince the farmers to adopt location-specific best management practices appropriate for the specific agro-ecosystem as the recommended packages of practices are the output of a scientifically evolved and rigorously tested and validated process.

In fact, the way forward is to utilize all the modern tools and techniques at the disposal of the scientists to evolve eco-friendly climate-smart and cost-effective management strategies with emphasis on resource input use efficiency that will lead to improvement in soil health and sustainability of the production system.

We need to emphasise that India’s agricultural success has essentially been due to the quality seed of new improved varieties/breeds replaced periodically as and when newer varieties are bred along with appropriate input management. The Academy strongly feels that it shall be the biggest undoing of the phenomenal success achieved by Indian Agriculture, if all the production zones of the country were to adopt ZBNF. This is likely to result in a significant drop of the national food grain production over the years, and with increasing pressures of climate change it may even drop below the half mark, landing the nation into scenarios of severe food shortages.

While the current projects by the *NITI Aayog* on validation of the technology or survey of impact on agriculture may be taken to logical conclusion, it is the firm opinion of the Academy that promoting technologies which essentially rely on crop varieties which have inherently low yielding potential would be detrimental to the Indian resolve of meeting the Sustainable Development Goals (SDGs), especially 1 and 2, as well as meeting the aim of doubling farmers' income. The nation cannot afford to compromise on the nutrient supply needed to overcome the silent hunger and the unethical perpetuation of high concentration of stunted and wasted children and anaemic mothers.

The Academy is of the considered opinion that there is no scope for an incremental value gained by the farmer or the consumer through ZBNF that represents one of the many such practices followed in India prior to the 1950s when no more than 50 Mt of food grains could be produced, making ZBNF a technology that lacks rationale or acceptability as a production technology.

Therefore, it is recommended that the Government of India should invest capital, efforts, time and human resources towards developing a strong research base and technologies to produce "More from Less for More" instead of promoting a technology like ZBNF.

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