A Critical Discussion on the Methods Currently Recommended to Support Organic Crop Farming in India

YL Nene

Chairman-Emeritus, Asian Agri-History Foundation; 47 ICRISAT Colony -1, Brig. Sayeed Road, Secunderabad 500009, Telangana State, India (email: yeshwantn2@gmail.com)

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Abstract

Excessive use and abuse of agro-chemicals during the "Green Revolution" period led to serious concerns about environmental pollution and that resulted in a shift to the "reduced chemical' or "non-chemical" farming methods. Beginning in 1990s, researchers and farm policy makers all over the world, including India, re-focused their attention to "organic farming". I have described and discussed most of the methods currently recommended in different parts of India. These methods are: (i) The natural way of farming or "Do Nothing" farming by Fukuoka, (ii) Biodynamic agriculture by Steiner – introduced in India, (iii) Vermi-culture developed by Appelhof– introduced in India, (iv) "Natueco" culture by Dabholkar, (v) Zero Budget Natural Farming by Palekar, (vi) Rishi-Krishi *by Deshpande, (vii)* Agnihotra *by disciples of Gajanan Maharaj of Akkalkot, (viii)* Panchagavya *by Natarajan, (ix)* Krishi-suktis *and* Vrikshayurveda *by sages and scholars of ancient and medieval India, (x) Compost tea by Ingham– introduced in India, and (xi) Bokashi tea by Higa– introduced in India. I have also discussed potential of all these methods in supporting food security of India.*

Modern-day organic farming in India

Since ages in India, the entire industry of agriculture was based on using organic techniques, where the fertilizers and pesticides were prepared from plant and animal products. Organic farming was the backbone of the Indian economy and owning a number of cows was equated with wealth. The cow not only provided milk but also provided bullocks for farm operations and dung as fertilizer. In addition, traditional farming since the ancient times included use of other methods of manuring such as night penning of sheep, green manuring, and applying non-edible oilcakes. I have not discussed these methods in this paper.

From 1905 to 1924, the British botanist Sir Albert Howard and his wife Gabrielle, herself a plant physiologist, worked as agricultural advisers and Howard was in-charge of a government research farm at Indore, where they documented traditional Indian farming practices and came to regard them as superior to their

conventional agriculture science. Their research and further development of these methods is recorded in his writings, notably his 1940 book, "An Agricultural Testament", which influenced many scientists and farmers of the day (Howard, 1943). By and large the British and the other Europeans were unaware of the excellent practices described in different *Krishisuktis* and *Vrikshayurvedas*.

During the 1950s and 1960s, the ever-increasing population of India, along with frequent natural calamities, led to a severe food scarcity in the country. As a result, the Indian government was forced to import food grains from foreign countries. To increase food security, therefore, the government had to take radical steps to increase food production. At this time Howard's work was placed in cold storage.

The "Green Revolution" became India's flagship in the mid-1960s. Several hectares of additional land were brought under cultivation. Hybrid seeds and new varieties of wheat and paddywere introduced. Natural and organic fertilizers were significantly replaced by chemical fertilizers and the traditional pesticides were replaced by chemical pesticides. Large chemical factories such as the Rashtriya Chemical Fertilizers Ltd. were established.

Before the "Green Revolution", it was predicted that millions of poor Indians would die of hunger in the mid-1970s. However, within a few years, the "Green Revolution" showed its impact. The country, which greatly relied on imports for its food supply, reduced its imports every passing year. In the 1990s, India had surplus food grains and had once again become an exporter of food grains to the rest of the world.

As time went by, extensive dependence on chemical farming showed adverse side-effects on crops. The land has been losing its productivity, thus increasing the demand for larger quantities of fertilizers every season. Some serious crop pests have developed resistance or immunity to crop-pesticides, requiring the farmers to use stronger and costlier alternative pesticides that resulted in polluting the environment. Due to the increased cost of farming, farmers started falling into the trap of high-interest loans, and their economic condition became deplorable beyond any imagination. The situation therefore compelled consumers, farmers, voluntary organizations, and the policy makers to look for alternatives for correcting the practices, thereby shifting gradually back to predominantly organic farming, based on innovations in traditional farming methods in India.

It is believed by many that organic farming is the much healthier and sustainable option. Although the health benefits of organic food are yet to be proven fully, consumers belonging to high income groups are willing to pay a higher premium for organic produce.

Many farmers in India are shifting to organic farming due to the domestic and international demand for organic food. According to the International Fund for

Agriculture and Development-IFAD, India is now becoming an important international supplier of organic food (www.ifad.org). The total organic area in Asia is nearly 2.9 million hectares. This constitutes nine percent of the world's organic agricultural land, and 230,000 producers were reported. The leading countries are China (1.6 million hectares) and India (1 million hectares) (Wikipedia, 2017). The history of this modern revival of organic farming was, to a great extent, an aftermath of "green revolution" wherein there was a growing reliance on new synthetic, non-organic methods. Reverting to organic agriculture began more or less simultaneously in Central Europe and India.

In the following paragraphs, some organic farming methods that are currently recommended in India are discussed. The last paragraph/*sin italics* contain my assessment of the method in the context of India's food security.

The natural way of farming or "Do-Nothing" farming

Masanobu Fukuoka (1913 –2008), a Japanese farmer and philosopher was a proponent of "no-till, no-herbicide grain cultivation" farming method, traditional to many indigenous ultures. This became known widely as "Natural Farming" or "Do-nothing Farming". Masanobu Fukuoka's book, "One-Straw Revolution", was first published in 1978 **(**Fukuoka Masanobu, 1985).

The principles of Natural Farming are: (i) human cultivation of soil, plowing or tilling are unnecessary, as is the use of powered machines; (ii) prepared fertilizers, preparing compost, and weeding are unnecessary, instead only minimal weed suppression with minimal disturbance; (iii) applications of pesticides or herbicides are unnecessary, and pruning of fruit trees is unnecessary.

In Japan, where Fukuoka had few followers or associates, his critics argued that the "inner world and the connection between humans and nature does not, however, exhaust reality". A lot of interest was generated in Fukuoka's method in India by a few ecologists, politicians, and the mass media. However, the large body of Indian farmers are not convinced about the practicability of Fukuoka's method.

From the hunter-gatherer stage in human evolution in which the "do nothing" farming was in practice, the mankind moved to plow agriculture for obvious benefit of ensuring food security. To me "do nothing" farming means to go back in time, which just can not happen.

Biodynamic agriculture

Bio-dynamic (BD) agriculture is a form of alternative agriculture similar to organic farming, but it includes various esoteric concepts drawn from the ideas of Rudolf Steiner (1861–1925), an Austrian philosopher, social reformer, architect, and "esotericist". Developed since 1924, it was the first of the "organic agriculture" movements in Europe. It treats soil fertility, plant growth, and livestock care as

ecologically interrelated tasks, and emphasizing spiritual and mystical perspectives.

Bio-dynamics has much in common with other organic approaches – it emphasizes the use of manures and composts and excludes the use of manufactured chemicals on soil and plants. Methods, unique to the BD approach, include its treatment of animals, crops, and soil as a single system, an emphasis from its beginnings on local production and distribution systems, its use of traditional and development of new local breeds and varieties. Some methods use an astrological sowing and planting calendar that was so common in ancient and medieval India. Biodynamic agriculture uses various herbal and mineral additives for compost and field sprays; these are sometimes prepared by controversial methods, such as burying ground quartz stuffed into the horn of a cow, which are said to harvest "cosmic forces in the soil".

There are certification agencies for BD products, most of which are members of the international bio-dynamics standards group Demeter International.

The movement started in India in the early 1990's. Peter Proctor, a farmer from New Zealand working in BD agriculture since 1965, was asked to come to India by Shri TGK Menon of Indore in 1993 to teach Indian farmers about BD farming. He & Rachel Pomeroy have been coming since then twice a year to run seminars, workshops, and courses for all farmers in villages or those running big estates. Interest in BD agriculture has greatly increased over the past five years among organic farmers in India. There are now more than 500 small and big farms practicing BD agriculture throughout the country. Three major initiatives located in the north and south are promoting BD agriculture among 3000 small farms. The Bio-Dynamic Association India Koramangala, Bangalore 560 034, India (BDAI) is committed to provide training on BD agriculture, to link up with the international Bio-dynamic Movement and to promote and support the trade and commerce connected with BD agriculture in India through interaction (Rajendran *et al.*, 2000; www.biodynamics.in). For stimulating humus formation, the BDAI recommends two main formulations:

- **500**: (cow horn-manure) a humus mixture prepared by filling the horn of a cow with cow manure and burying it in the ground (40–60 cm below the surface) in the autumn. It is left to decompose during the winter and recovered for use the following spring.
- **501**: Crushed powdered quartz prepared by stuffing it into a horn of a cow and buried into the ground in spring and taken out in autumn. It can be mixed with formulation 500, but usually prepared on its own (mixture of 1 tablespoon of quartz powder to 250 liters of water). The mixture is sprayed under very low pressure over the crop during the wet season, in an attempt to prevent fungal diseases. It should be sprayed on an overcast day or early in

the morning to prevent burning of the leaves. The application rate of the bio-dynamic field spray preparations (i.e., **500** and **501)** are 300 grams per hectare of horn manure and 5 grams per hectare of horn silica. These are made by stirring the ingredients into 20-50 liters of water per hectare for an hour, using a prescribed method.

Beneficial outcomes of practicing BD have not been scientifically established between certified BD agricultural techniques and similar organic and integrated farming practices. Research into BD farming has been complicated by the difficulty of isolating the distinctively BD aspects when conducting comparative trials. Consequently, there is no strong body of material that provides evidence of any specific effect. Acceptance of BD practice by farmers has been minimal, and possibly has no future in India.

Vermi-culture

Modern day Vermi-culture was inspired by Mary Arlene Appelhof (1936-2005), an American biologist, "Vermi-composter", and environmentalist. As a Michigan (USA) biology teacher, Appelhof in 1972-73 wanted to continue composting in winter months even though she lived in a temperate climate. She ordered worms from a bait shop nearby and set up one of the first indoor composting systems. She found her composting system to be a success.

Vermi-compost is the product of the composting process using various species of earthworms, to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and Vermi-cast. This process is called Vermi-composting. Vermi-cast (also called worm castings, worm humus, or worm manure) is the end-product of the breakdown of organic matter by an earthworm. Vermi-compost contains water-soluble nutrients and is therefore a nutrient-rich organic fertilizer and a soil conditioner. Increases in the total nitrogen content in Vermi-compost, an increase in available nitrogen and phosphorus, as well as the increased removal of heavy metals from sludge and soil have been claimed.

Exotic species of earthworms have been used in India for Vermi-composting. Internationally, three species have been found more efficient than others; these are the exotic *Eisenia foetida* and *Eudrilus eugeniae*, and the endemic *Perionix excavates.* There is no need to import earthworms from elsewhere as in the past; local species of earthworms, *P. excavatus* and *Lampito mauritii,* have been found equally efficient.

Bhawalkar Earthworm Research Institute (BERI) was set up in India in 1981 by Uday Bhawalkar (Sinha *et al*., 2010). BERI has established six large-scale Vermi-composting projects, and motivated nearly 5,000 farmers in 16 Indian states to use worms in their farming practices. Results of several experiments have proven that Vermi-culture can contribute significantly to crop yields and quality, and quadrupling grass pasture production. Savings on input costs such as fertilizer and water have dramatically increased profits.

Over the last 15 years, Maharashtra Agricultural Bioteks (MAB) in Pune, India has prompted over 2,000 farmers and institutions to switch from conventional chemicals to the organic fertilizer, Vermi-compost. In 1991-92, MAB and the Indian Department of Science and Technology promoted the adoption of Vermi-compost technology in 13 states in India. The group has also established a Vermi-compost unit with Chitrakoot Gramodaya University, Madhya Pradesh, which produces five tons of Vermi-compost per month (Jambhekar – Personal communication).

The positive effects of Vermi-compost are due to microbial activities, which aremost likely associated with plant growth regulators and increased levels of humic acid and folic acid found in Vermi-compost. Increased growth effects were more frequent and more pronounced at specific concentration levels and application rates. Optimum germination, growth, flowering, and heavier yields occurred only in a specific formulation that included nutrients other than what is in the Vermi-compost (Kale Radha and Karmegam, 2010).

Earthworms restore and improve soil fertility and significantly boost crop productivity. Earthworms excreta (Vermi-cast) is a nutritive organic fertilizer rich in humus, NPK, micronutrients, beneficial soil microbes --nitrogen-fixing and phosphate-solubilizing bacteria and actinomycetes, and growth hormones auxins, gibberellins, and cytokinins. Both earthworms and its Vermi-cast and body liquid (Vermi-wash) are 'growth promoters and protectors' for crop plants.

Too much Vermi-compost can block the functions that trigger the positive responses. Another negative feature might be that the Vermi-compost with epigeic earthworms such as Dendrobaena veneta and Perionyx excavatus in soil and compost may aid proliferation of Escherichia coli in early stages of contamination, long-term persistence of the pathogen appears to be unaffected (Prysor et al., 2006). It is used in small-scale, sustainable, organic farming. Vermi-culture has potential to be used by farmers on large scale. More studies are needed on this health-related issue (Asgrow, 2017).

Natueco culture

Dabholkar (2001) coined the word "Natueco" that combines two words together, "Natural" and "ecological". Natueco has been conceived of as a holistic way to meet our farming and food requirements. It addresses serious issues of a farm, like (i) staying in synergy with Nature, (ii) reducing dependency on external inputs to a farm, and (iii) working scientifically within the available resources in the surroundings of a farm, without harming its ecology and at the same time gaining high benefits from it.

According to Dabholkar, the features of Natueco culture distinguish it from the "Natural Farming" and/or "Organic Farming"; and he calls it "Beyond Organic Farming". He explains that Natural or Organic farming is done trusting Nature

through the empirical wisdom of the ages. In Natueco Farming, however, farming is done by knowing Nature better through critical scientific inquiries and experimentation.

The key features of this Natueco farming technology of growing crops are: (i) plants are grown on small heaps of *Amrut Mitti* (nectary soil), the Natueco process of building fertile soil covered with mulch, hence no ploughing, *Amrut Mitti* is the key ingredient - a compost - in the form of heaps that are always kept moist, (ii) need-based sowing and harvesting of crops, (iii) does not need any external input in terms of the agro-chemicals, (iv) weeds are allowed to grow until flowering and are seen as a resource, (v) high diversity on a small piece of land - over 125 crop species with a mix of annuals and perennials, (vi) trenches around the farm for rain water harvesting, and (vii) live fencing around each farm created for multiple purposes.

Amrutjal (nectary water) is prepared by mixing 10 liters of water, 1 liter of cow urine, 1 kg of fresh cow dung, and 50 grams of jaggery. Ferment this mixture for 3 days, stirring it well twice or thrice each day. On the 4th day, the concentrated suspension is ready. One part of this suspension is diluted to ten parts with water. *Amrut Mitti* is prepared from green and dry plant biomass, both are dried and crushed well. The dried biomass is immersed in *Amrutjal* in a container and then kept as such for 24 hours. Dabholkar's Natueco method was popularized by Suchde (2011), who explains that it is possible to create a micro-climate to assure self-sufficiency. It follows the principles of nature's ecosystem in our farming systems and emphasizes harvesting through a critical application of scientific inquiries and experiments that are rooted in the local resources.

***Natueco farming has potential for gardeners and orchardists. It is not suitable for large-scale farms. The method may partially contribute to food security. One should note that the method takes an important component from* Kunapajala *preparation, that is fermentation of* Amritjal. *Thus, one of the components,* Amritjal *is a variant of* Kunapajala.**

Palekar's Zero Budget Natural Farming

The Zero Budget Natural Farming (ZBNF) has 4 key elements; *Bejamrita* (seed treatment), *Jiwamrita* (microbial culture), *Achhadana* (mulching), *Waaphasa* (soil aeration), according to Palekar (2005, 2006). *Jivamrita* is a fermented microbial culture, like the *Kunapajala* of *Vrikshayurveda* that is discussed later. It provides nutrients, and also acts as a catalytic agent that promotes the activity of microorganisms in the soil including that of earthworms. During the 48-hour fermentation process, the aerobic and anaerobic bacteria present in the cow dung and urine multiply as they decompose the organic ingredients (like pulse flour). A handful of virgin soil is also added as native microflora. *Jivamruta* also helps in preventing fungal and bacterial plant diseases. Palekar suggests that *Jivamruta*

is needed only for the first 3 years of the transition to ZBNF, after which the system becomes self-sustaining. To prepare *Jivamruta*, 200 liters of water are placed in a barrel and following materials are added: 10kg fresh local cow dung, 5 to 10 liters aged cow urine, 2 kg of cane jaggery, 2 kg of pulse flour, and a handful of virgin soil. The mixture is fermented for 48 hours in the shade. Two hundred liters of *Jivamruta* were found sufficient for one acre (0.4ha) of land. *Jivamruta* is applied to the crops, twice a month, through irrigation water or as a 10% foliar spray.

Bijamrita. It is used for seed dressing or root-dipping. *Bijamrita* is effective in protecting young roots from soil-borne and seed-borne pathogens that commonly affect plants especially after the monsoon period. It is composed of similar ingredients as *Jivamruta* - local cow dung and cow urine, lime, and soil. Application of seed dressing is done prior to sowing by adding *bijamrita* to the seeds of any crop, coating by mixing with hand, and drying them well. For the pulses seed, quick seed-dipping and drying is done.

Acchadana. (Sanskrit-*acchadana* means "to cover") means Mulching. According to Palekar (2005, 2006), there are three types of mulching: (i) Soil mulch -this protects topsoil during tillage-it promotes aeration and water retention in the soil, (ii) Straw mulch -straw material usually refers to the dried biomass waste of previous crops, but Palekar also suggests, it can be the compost of the dead material of plants, animals, etc.); this would provide dry organic material that will decompose in due course, and form humus through the activity of the soil biota,(iii) Live mulch (symbiotic intercrops and mixed crops) - this is essential to develop multiple cropping patterns of monocots and dicots grown in the same field to supply all essential nutritive elements to the soil and crops. Palekar's justification is that the legumes (dicots) are nitrogen-fixing plants, whereas the monocots such as rice and wheat would supply other elements like potash, phosphate, and Sulphur.

Whapasa. It is vapor-moisture. Palekar challenges the idea that plant roots need a lot of water, thus questioning reliance on irrigation. According to him, roots need water vapor. *Whapasa* is the condition where there are both air molecules and water molecules present in the soil.Palekar encourages reducing irrigation by irrigating only at noon and in alternate furrows.

Palekar's ZBNF is clearly suitable for small farm operations. It may contribute to partial food security. Features similar to methods of Kautilya, Dabholkar, and* Vrikshayurveda(Kunapajala) *are present.

Rishi-Krishi Deshpande Technique Methodology (RKDT)

This technique is similar to ZBNF of Palekar described earlier. Deshpande (2005) claims that the technique is based on *Vedic* literature and cosmic energy (Table 1). The aim of *Rishi-Krishi* (literally

"Sage-Agriculture"), as claimed, is to keep the soil "alive" forever with the help of cosmic energy, which is the only source of energy for plant growth. There are four "steps": (i) *Angara* (Holy Ash) that consists of 15 kg soil from the base of a banyan tree (a sacred tree) to increase in the population of the living organisms in the soil. According to Deshpande, such soil is biologically rich, as it has the excreta of birds, fallen leaves, and the adventitious roots have hormones and enzymes for reproduction; confirmed by Patil *et al* (2015), (ii) Preparation of *Amrut Pani* – [*Amrit* (Sanskrit: *am ta*) is a word that literally means "immortality"; in meaning somewhat close to ambrosia. *Pani* is water]. Materials used are one-quarter kilo ghee from an indigenous cow breed; one-half kilo of honey; 10 kilos of fresh dung from a *desi* cow; and 200 litres of water. The procedure is to thoroughly mix ghee with cow dung and then blend honey with this mixture. Two hundred liters of water are added while stirring continuously. The mixture thus obtained is called *Amrut Pani*. The blend was prescribed by Kautilya (c. 300 BCE). Two hundred litres of *Amrit Pani* is needed for one acre (0.4 ha). Sugarcane, turmeric, ginger, etc. should be planted after dipping into *Amrut Pani*. Roots of seedlings are dipped into *Amrut Pani* before transplanting. While watering sugarcane and other crops with canal or well water, mix *Amrut Pani* in the main watering channel stirring all the time. The seeds need dressing for rain-fed or the monsoon crops. After sowing, when the soil has moisture, it should be drenched with *Amrut Pani*. The drenching should be between the rows and not directly on the plantings. For seedlings of crops, such as chili, tobacco, or fruit trees, small amount of water that is needed to wet the area around; instead use of *Amrut Pani* is recommended. Excess of *Amrut Pani* is always beneficial and will not harm young plants; (iii) *Beej Sanskar* (dressing of seeds for planting); for dressing of seeds with a hard coat such as rice, wheat, corn, bhindi (okra) etc., a thick paste by mixing one kilo of *Angara* and sufficient *Amrut Pani* is prepared; and (iv) *Achhadana* (mulching), which is similar to that described earlier.

The RKDT has similarities to methods of Dabholkar and Palekar. The method is suitable for farmers with small holdings. RKDT may contribute food security only partially. No fermentation as in* Kunapajala *is involved in preparing* Amrut Pani. *It is used fresh after making.

Agnihotra

No ancient text on agriculture mentions *Agnihotra* as a farm-related ritual. *Agnihotra* is known as a ritual to seek prosperity for the family. It is a prayer to the Vedic God *Agni* ('Fire'), first prescribed in the *Yajurveda* (events-c.7000 BCE), and later elaborated in the *Atharvaveda* (c.1000 BCE). *Agnihotra* was that fire that was burnt at the time of marriage. The person was supposed to carry the fire home and there after keep it burning till the end of his life. This fire was kept burning all the time without letting it get extinguished. And every other fire that was used in the house like cooking, heating and other

domestic application was basically coming from that original *Agnihotra* fire. And the people who were following this kind of rituals were called as "*Agnihotris*".

In 1969, *Param Sadguru* Shri Gajanan Maharaj of Akkalkot, Maharashtra State, India (1918 - 1987), widely known as "Shree", initiated Vasant Rao Paranjpe and MG Potdar, in his spiritual path. Mr Potdar propagated *Agnihotra* message right from 1963 to 1974 i.e. till his passing away from this world. He worked with farmers mainly in Central India. On orders from the *Sadguru*, Paranjpe went to Peru in 1972 to spread *Agnihotra* over there. The reason for Paranjape's going to a far-off land to demonstrate *Agnihotra* are not disclosed. In 1996, Paranjpe selected in Nueva Requena, Peru, an area of three hectares of bananas, which was seriously affected by the Sigatoka-black disease and looked nearly dead. It was claimed that the disease was completely controlled.

There are plausible reasons for the beneficial influence of *Agnihotra*. Knowledge that we have today reveals that the materials used in *Agnihotra* sacrifice produce and release biochemicals to the atmosphere through smoke, which could eliminate or reduce harmful bio-pollutants, and thereby purifying the environment (Nene, 2014).

Paranjape's *Agnihotra* is the basis of *Homa* Farming. (*Homa* is a Sanskrit word that refers to a ritual, wherein an oblation or any religious offering is made into fire). However, *Homa* is more accurately a "votive ritual". The fire is the agent, and the offerings include those that are material and symbolic such as grains, clarified butter, milk, incense, and seeds. If cow dung and ghee are readily available they should be used in greater quantity when doing *Agnihotra*. The *Agnihotra* copper-pyramid is believed to be a generator of life-sustaining energies (www. agnihotra. org., 2015).

According to the followers of Paranjpe, treating seeds by following the *Homa* Therapy can make them more disease and pest resistant that would give an initial boost. For backyard plantings/small gardens: (i) placing seeds in cups or jars and labeling each container with the name of the seed, (ii) covering seeds with cow's urine and soaking them for one to two hours, depending on the size and nature of the seed; large seeds for 2 hours and small seeds for one hour, and (iii) removing the seeds and covering them in moist cow dung and the *Agnihotra* ash spreading before semi-drying them. The mixture can then be crushed and sown.

Ash from other *Homas* may be used in addition to *Agnihotra* ash in compost or applied directly onto the field. *Agnihotra* ash is believed to be the key to success; *Agnihotra* ash water solution is very useful for natural control of difficult pests and enhancing plant growth. The ash contains oxides of silicon, sodium, potassium and magnesium; carbonates are also formed by the oxides reacting with the carbon dioxide

The* Agnihotra *farming method, adapted for use in farming only recently can be practiced by individual orchardists or

***village groups. The method can contribute only a little to food security. Smoke was prescribed in* Vriksh-ayurvedas.**

Panchagavya

For the Hindus, the formulation and use of fresh *Panchagavya* has been well-known, since the time of *Puranas* (c. 200 BCE to c.750 CE) for house purification after deaths, etc. It's use as a fermented product with adjuvants such as cane jaggary and coconut water has only recently been extended for use in crop farming.

Dr. K Natarajan, [President, Rural Community Action Center (RCAC), Kodumudi – 638151, Tamil Nadu], a physician and a disciple of Swami Jeevananda, thought of using *Panchagavya*, after he had read the books of Fukuoka and Carson. Theories and concepts of organic agriculture were developed and popularized under different names, viz., organic agriculture, green culture, natural farming, and do-nothing farming, etc. The enlightened public started demanding toxin – free food products. The market demand for organic produce gave further momentum to the organic movement, all this stimulated Natarajan to use *Panchagavya* in farming.

According to Natarajan (2003), *Panchagavya*, also spelled as *Panchkavya*, an organic product has the potential to play the role of promoting growth and providing immunity in plant system. *Panchagavya* consists of nine products viz. cow dung, cow urine, milk, curd, jaggery, ghee, banana, tender coconut, and water. When suitably mixed and used, Natarajan claims "miraculous" effects on treated crops.

The following items are mixed and fermented, in a large container, in steps, for 30 days; cow dung - 7 kg; cow ghee - 1 kg**;** cow urine - 10 liters**;** water - 10 liters; cow milk - 3 liters; cow curd - 2 liters; tender coconut water - 3 liters; and cane jaggery - 3 kg. The mixture is stirred well. This is called "stock solution". Natarajan insists on products from "Indian breeds of cow", and avoiding products from buffalos.

Generally, *Panchagavya* is recommended for all the crops, as foliar spray at 3% level (3 liters *Panchagavya* in 100 liters of water), in irrigation water (50 litres for one ha), as dipping seed and planting materials, or before seed storage.

Panchagavya *has gained popularity with farmers in several states of India, especially southern India. It has excellent potential to contribute to food security. It should be noted that* Panchagavya*, as modified by Natarajan, is essentially* Kunapajala *minus flesh. Thus, we could call it a* Kunapajala *variant.*

Krishi-suktis and *Vrikshayurveda*

The Indian science of health management, *Ayurveda*, was well-documented by the time of Susruta (c.400 BCE), a surgeon, and Charak (c.700 BCE), a physician. Cotemporary physicians began applying the knowledge of *Ayurveda* to domesticated animals and the garden plants, especially the perennials such as shrubs and trees. Our ancient and medieval

agricultural texts basically describe what we now label as "organic farming" and also described the operations required for production of all kinds of crops - grain, fiber, sugar, fruit, vegetable, and others.

Rigveda includes references to field agriculture and animal husbandry (Nene and Sadhale, 1997). Sanskrit texts on farming of field crops and animal management were called *Krishi-suktis* (*Sukti* is a Sanskrit word which means "Wise Saying", good or friendly speech, Verse, or Stanza). The first well-known text on *Krishi-sukti* was *Krishi-Parashara* (c. 400 BCE). Another one was *Kashyapiyakrishisukti* by Kashyapa (c. 800 CE**;** Ayachit, 2002). A few texts written in later centuries have also been unearthed.

Krishi-Parashara (*KP*) is probably the first-ever 'textbook' on agriculture in which information is logically organized in chapters. *KP* deals in details the parts of plow and other implements of the time, agronomic practices and management - in principle similar to modern ones, cattle sanitation, health, and nutrition, seed health, and prediction of seasonal rainfall based astrological models that are followed by thousands of farmers even today. Manures used were the stored cow dung and excreta from other farm animals; and then small balls of the manure were placed in seed-sowing furrows (Sadhale, 1999).

The text of *Kashyapiyakrishisukti* covers practices followed in growing irrigated rice, advises rulers to provide strong support to farmers and their activities, management of water reservoirs, stresses participation of people of all castes in farm-related activities, efficient soil management, and cattle management (Sadhale, 2004). Manures were similar to those described by Parashara.

The first mention of *Vrikshayurveda* is found in Kautilya's *Arthsastra* (c.300 BCE; Shamasastry R. 1961 but even by the time of Varahamihira (505 – 587CE), who compiled *BrihatSamhita* (Bhat, 1981), the science of *Vrikshayurveda* was in early stages. The first systematic text on *Vrikshayurveda* was written in Sanskrit by Surapala (c. 1000 CE). It's translation in English was published first time by the Asian Agri-History Foundation (AAHF) in 1996. Almost around the same time, *Lokopakara* (1025 CE) in old *Kannada* was compiled by Chavundaraya in Kalyani, near Bidar in northern Karnataka (Ayangarya, 2006**).** Subsequently, texts on *Vrikshayurveda* with titles, such as *Upavanavinoda*, *Vishvavallabha*, etc., were compiled.

All five *Vrikshayurvedas* emphasized gardening, raising and managing herbs, flowers, fruits, and vegetables. Most practices followed were similar to the modern ones. The most significant innovation, probably first time in world agri-history, was the development of fermented liquid manures from organic wastes – *Kunapajala* (literally filthy fluid) or *Kunapambu* (fermented filth). *Kunapajala* could be used for seed-dressing, soil drench, or for sprinkling on plants.

Surapala's procedure involves collecting and storing animal wastes as and when available. Although wastes from dead boar were mentioned first, Surapala (Sadhale, 1996) expanded the source of wastes to other animals, especially those with horns. The wastes are cooked and then stored after mixing husk. When needed for use, addition of sesame oil cake, honey, and soaked black gram, and finally the ghee. The suggestion to store animal wastes underground (anaerobic?) was possibly to contain foul odor, as also to protect materials from omnivorous scavengers. Surapala has mentioned that wastes from other animals such as cow, porpoise, cat, deer, elephant, etc. can be used. In addition to these, animal skin was suggested by Chakrapani. *Kunapajala* can be prepared from virtually any animal waste and, therefore, gives flexibility to farmers in preparing *Kunapajala* according to their convenience.

It is generally accepted that plant roots utilize chemical fertilizers faster than organic manures. This is true when the organic manures, which are soft and semi-dry, are scattered in the field. Application of *Kunapajala* is different from those of other organic manures. *Kunapajala* is a liquid and therefore ready to reach root zone in a short time. Secondly, the ingredients of *Kunapajala* have been fermented, which means the mass (proteins, fats, etc.) is already broken down into simple low molecular weight products, and therefore, these would become available to plants faster than from the traditionally applied organic matter (Neff *et al*., 2003). It is only the farmers and sages of ancient India who took pains to formulate and use improved organic manure mainly for perennial plants. Spraying diluted *Kunapajala*, with excellent sprayers, is a modern innovation.

Valmiki's insecticide- *Indsafari* is a fermented product of '*safari',* a tiny weed fish, in cow urine (Ayangarya, 2005). This preparation is in line with the recommendation of Chakrapani Mishra in *Vishvavallabha* (Chapter VIII, Verse 39), wherein to control "external" insects, powders of the barks of *aragvadha (Cassia fistula), arishta (Sapindus emarginatus), karanja (Pongamia pinnata), saptaparna (Alstonia scholaris),* and *bidanga (Embelia ribes)* soaked overnight in cow urine, are pasted on affected parts. The *saphari* fish was suggested as manure for rice by Kautilya (Nene, 2002). Cow urine contains chemical labeled as "bioenhancer" that increases efficacy of the drug/active principle mixed withcow urine (Khanuja *et al*., 2003).

Indsafari is sprayed on foliage for control against all sorts of insect pests, and in particular the Looper caterpillar (caterpillars of three major species, *Hyposidra talaca, H. infixaria,* and *Buzura suppressaria*). Cow urine is also used to ferment *Polygonum aviculare,* a weed with swollen knobby joints on its stems that is found in abundance in the tea-growing regions of the north east. The resulting liquid is sprayed against Red- spider mites. To control the tea-mosquito, Parmar

(2017) formulated fermented solution of *Vitex negundo* or *Clerodendrum infortunatum*, the plants commonly found growing by the roadside across West Bengal, the Northeast, and Nepal. This concoction is very effective in controlling *Helopeltis theivora*.

The liquid organics* Panchagavya *and* Kunapajala *individually as well as in combination proved their efficacy in promoting the growth and yield attributes of vegetables crops (Sarkar et al., 2014). The degree of efficiency of individual treatments varied but* Panchagavya + Kunapajala *together were found to be best in better utilization of leaf nitrogen, efficient photosynthetic activity, and in improving yields. In the modern-day farming, with increase in organic inputs in the of high value vegetable crops, use of such growth promoters through soil drenching, will be efficient and economically better choice for the farming community. At the same time* Panchagavya+ Kunapajala *can be used as prophylactic measure against the disease incidence of vegetable crops.It is to be noted that fermented* Panchagavya *is also a variant of Kunapajala.* Kunapajala *of Surapala contains flesh unlike* Panchagavya. Panchagavya *plus* Kunapajala, *no wonder, gave better results than either of them (Sarkar et al., 2014).* Kunapajala *can be beneficial in growth of medicinal plants with probably minimal toxic effects on human body when compared to chemical fertilizers.* Kunapajala *does produce phenomenal and interesting results. The Kunapajala preparation and application techniques need to be researched more Bhat et al. (2012).

Other concoctions

Compost tea. It is claimed by Brehaut (1933) that methods for brewing compost teas date back to early Roman, Greek and Egyptian times. Names of Cato the Elder (234 BCE – 149 BCE) and Pliny the Elder (AD 23 – AD 79) have been mentioned as the documenters. No further details are available in the literature for verification of this 'history'.

The Compost tea received a boost since late 1990s; this specific term and technique was developed by Dr. Elaine Ingham, well-known soil scientist. Use of Compost tea is popular in the West. It is a liquid extraction of nutrients and microorganisms from finished compost or worm castings used as a foliar spray or soil amendment. Compost tea can be made by leaching the nutrients and microorganisms with aeration. Often, other supplements are added during the steeping process to aid in the proliferation of the beneficial microorganisms and bacteria. Molasses are added as a food source for feeding the bacteria (Ingham, 1999).

***Bokashi* "tea".** Dr. Teuro Higaof Japan, developed around 1982 a technology using Effective Microorganisms (EM), which is also called *Bokashi* composting, (*bokashi*

Table 1. A Summary of methods of crop farming in India.

Method	Innovator/year	Constituents	Scope/Future	Other Comments
"Do Nothing"	Fukuoka, 1978. Japanese farmer and philosopher.	Nothing except minimal weeding	It will not be widely accepted	Impossible to have food security
Biodynamic	Steiner, 1924. Austrian Philosopher.	Cow horn manure and cow horn quartz (silica)	Very limited following	No major contribution to food security
Vermi-culture	Ms Applehoff 1972-73. Michigan biology teacher and environmentalist.	Use of earthworms to enrich compost with nutrients	Has potential for use on large scale.	Can contribute to food security
Natueco-culture	Dabholkar, 1967. Mathematician in Sangli (MS) who inspired organic farming method.	Mulching-no plowing; *Amrut Mitti*-a name given by Late OP Rupela; compost strips made for raising crops; *Amrut-Jal*-fermented cow dung and urine with jaggary. Applied as nutrient liquid.	Has the potential for gardeners and orchardists. Not suitable for large scale farms.	Can partially contribute to food security. Fermented liquid is a variant of Kunapajala
Zero budget Natural farming	Palekar, 2005-06	Four key elements: *Beejamrita*-seed treatment, *Jevamrita*-fermented microbial culture, *Achhadana*-mulching, and *Waaphasa*; no irrigations	For small scale operations	Partial food security. Features similar to Kautilya, Dabholkar, and Kunapajala are present.
Rishi-Krishi	Deshpande,1970. Science graduate majoring in mathematics. With his land in district Kolhapur (MS), he developed a passion for experimental agriculture,	Four steps: *Angara*-soil from Banyan tree trunk; *Amrit-Pani* [ghee, honey, cow dung in water; *Beej Sanskar* [seed dressing with paste of *Angara* and *Amrit-Pani,* and *Achhadana* [mulch].	Has similarities to methods of Dabholkar and Palekar. Suitable for small farmers.	Can contribute to partial food security. No fermentation.

Method	Innovator/year	Constituents	Scope/Future	Other Comments
***Agnihotra /Homa* farming**	Potdar Inspired and Paranjpe by "Sadguru". 1970 to 2000.	Ghee, grains, milk, piece of dried cow dung burnt in copper pyramid. Smoke purifies the air around.	Can be practiced by individual orchardists or a village group.	Can contribute a little to food security. Smoke was prescribed in *Vrikshayurvedas.*
Panchagavya	K Natarajan, 2003, a physician, Kodumudi, Tamil Nadu.	Mixing 5 products of cow, coconut water and cane jaggery. Fermented for 30 days. Seed dip, soil drench, foliar paste.	*Panchagavya* has gained popularity with farmers in several states of India	Excellent potential to contribute to food security.
Krishi-suktis* and *Vrikshayurveda	Parashara [c.400 BCE], Kashyapa [c. 800 CE], Surapala [c. 1000 CE]	Sound practices for raising of crops. Animal dung manure to field crops and *Kunapajala* [KJ] mainly for perennial crops. KJ is a fermented liquid manure prepared from flesh, animal and plant wastes, and cow products.	*Kunapajala*has gained limited popularity because use of flesh is unacceptable to most people. Fermented *Panchagavya* does not have flesh and therefore readily acceptable.	Excellent potential to contribute to food security. Also waste management.
Compost tea and *Bokashi* tea	Elaine Ingham, soil scientist.1990s	Liquid extraction of nutrients and microbes from finished compost, molasses added.	Anaerobically composted animal and plant wastes, bran, inoculated with "effective microbes"	Has gained popularity in several countries. Can contribute to food security.

in Japanese means or "gradation" or fermented organic matter). It is claimed that Bokashi composting, originate in the far east, with many researchers specifying Japan or Korea as the first country to use. The truth is that *Kunupajal* was first formulated in 1000 CE.

The EM or *Bokashi* composting is an anaerobic process, which relies on inoculated bran to fermented kitchen waste, including meat and dairy. It is a safe soil builder and nutrient-rich tea. The inoculum is a consortium culture of different "effective" microbes commonly occurring in nature. Most important among them are: N2-fixers, P-solubilizers, photosynthetic microorganisms, lactic acid bacteria, yeasts, plant growth promoting rhizobacteria, and various fungi

and actinomycetes. In this consortium, each microorganism has its own beneficial role in nutrient cycling, plant protection and soil health and fertility enrichment.

Organic fertilizer that was inoculated and fermented with a microbial inoculant (EM) contained large populations of propagated *Lactobacillus* spp. Actinomycetes, photo-synthetic bacteria, and yeasts; high concentrations of organic acids and amino acids (intermediate compounds); 0.1% of mineral nitrogen mainly in the ammonium (NH_4+) form, and 1.0% of available phosphorus; and a C: N ratio of 10 (Xu *et al*., 2008).

The EM inoculation to both *Bokashi* and chicken manure increased fruit yield of tomato plants. Concentrations of sugars and organic acids were higher in fruit of plants fertilized with *Bokashi* than in fruit of other treatments. Vitamin C concentration was higher in fruit from chicken manure and *Bokashi* plots than in those from chemical fertilizer plots. Both fruit quality and yield could be significantly increased by EM inoculation to the organic fertilizers and application directly to the soil (Yamada and Xu, 2001).

The use of Effective Microorganisms (EM) is certainly a technology that deserves considerable and serious attention. Its beneficial potential for creating a sustainable world is too promising to be ignored (Freitag and Meihoefer, 2000). An argument raised by "eco-purists" is the fact that the introduction of EM into soils alters the natural chemical composition of the soils, displacing native microorganisms and nutrients, which may be harmful to the survival of native plant species (Smith, 2001). This may be true, and more research is required on soiltructure at local levels.

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