Relevance of *Vrikshayurveda* and Traditional Knowledge for Eco-friendly Sustainable Agriculture to Meet SDGs in India

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Abstract

In India, agriculture occupies a special place in its economy as it supports majority of its population (about 60-70%) for their livelihoods. Agriculture in ancient and medieval India was considered sustainable because of the use of age-old and traditional farming practices. However, the English in the early- to mid-20th century replaced the traditional Indian agriculture by the European agricultural practices. Post-independence, in the urgent need for maximization of agricultural production high yielding wheat and rice varieties with high inputs (fertilizers and pesticides) were used, which resulted into "Green Revolution" and self-sufficiency in food grains. However, this gain with it brought a number of ill-effects on Indian agriculture related to soil degradation, underground water pollution, chemical pollution of fruits and vegetables, and adversely affected the eco-friendliness and sustainability. In this context, the time-tested traditional agriculture practices especially of Vrikshayurveda have shown a tremendous relevance and potential as evidenced by the encouraging validation results. Thus, the small-holder farmers could benefit by using only Vrikshayurveda and traditional practices; whereas the mid- and large-scale farmers could integrate them into their farming to ensure judicious use of modern technology. For this, need for a policy shift in agricultural education and research to support and strengthen the validation research and create greater awakening among all the Indian agriculture stakeholders and their possible role in meeting the Sustainable Development Goals (SDS) is discussed.

India can be characterized basically as an agriculture-dependent country as the majority (about 60-70%) of its population depends upon agriculture for their livelihoods. The country had been following the traditional system of farming adopting the age-old practices which made it sustainable and provided

food security to their populations (Nene, 2007, 2012a; Prasad *et al.*, 2016). Indian agriculture even survived the onslaught of outside invaders. However, it was in the early 17th to late 19th century (1600-1900 CE) that the English introduced the European agricultural practices in Indian agriculture with the introduction of their animal and tractor-drawn implements together with chemical fertilizers and pesticides. However, with many-fold increase in population in post-Independent India it became exceedingly difficult to feed the growing population and the country had to import food grains to meet its demand. With the ushering of the "Green Revolution' in mid-1960s to mid-1970s India achieved significant increases in wheat and rice production making the country self-sufficient in food grains. However, in the urgent need for maximization of food production, it was not visualized that the modern high-input agriculture could have serious adverse impacts on soils, environment, and human health. Now, the greatest challenge before the country is to make the present agriculture system eco-friendly and sustainable. For this, one option available is the use of our ancient, time-tested practices of *Vrikshayurveda* and traditional farming systems to make Indian agriculture eco-friendly and sustainable. It is in this context, this article discusses the relevance and potential of these practices to achieve the eco-friendly and sustainable agriculture, and how it could help in meeting the Sustainable Development Goals (SDGs) of the United Nations in India by 2030.

Indian agriculture through ages

India is an ancient and the oldest form of civilization with rich agricultural heritage since the time of *Rigveda* (Nene, 2007, 2012a; Prasad *et al.*, 2016). Agriculture and animal husbandry in India developed in Indus and Sarasvati Valleys of Bharatvarsh (present India and Pakistan) over 6,000 years ago. Vedas (*Rigveda, Samaveda* and *Yajurveda*) do mention wooden plough, barley, inter-culture, harvesting, threshing, storage, animal (cow) management, and agriculture as the main occupation of the ancient Hindus.

The Indus Valley civilization. The civilization, more correctly called the Indus-Sarasvati Rivers Civilization, was considered a prosperous civilization which flourished during 6,000-4,000 BCE (Nene, 2018a). Its agriculture produced surplus grain, which was shipped to West Asia, and North and East Africa. The civilization and agriculture flourished in the Indus Valley Civilization.

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Ancient classics on agriculture. Asian Agri-History Foundation is credited with unearthing several ancient classics on agriculture starting with *Krishi-Parashara* (Agriculture by Parashara) by Parashara (c. 400 BCE) " the first-ever text book on agriculture (Sadhale, 1999) to *Vrikshayurveda* (The Science of Plant Life) by Surapala (c. 1000 CE), the first ever complete text in Sanskrit on arbori-horticulture in the world (Sadhale, 1996). *Krishi-Parashara* highlights the importance of good management in farming using examples of relevance to that time, whereas *Vrikshayurveda* describes a unique liquid fertilizer-cum-plant protection material called *Kunapajala,* prepared from animal wastes subjected to fermentation. Surapala's *Vrikshayurveda* contains extremely useful information for organic farming and most of the practices developed and now being used in India for organic farming originate from Surapala's *Vrikshayurveda*.

Besides the above two books, several other texts in Sanskrit and other Indian languages were written during 800-1600 CE in Bharatvarsh which included: *Kashyapiyakrishisukti* (A Treatise on Agriculture by Kashyapa) (c. 800b CE) (Ayachit, 2002); *Lokopakara* by Chavundarya (1025 CE) in old Kannada (Ayangarya, 2006); *Upavanavinoda* (Woodland Garden for Enjoyment (c. 1300 CE) by Sarangadhara in Sanskrit (Sadhale, 2011); *Mrigapakshishashtra* (The Science of Animals and Birds) by Hamsadeva (c. 1300 CE) in Sanskrit (Sadhale, 2000); *Krishi Gita* (Agricultural Verses) by Parashurama (1500 CE) in Malayalam (Mohan Kumar, 2008); and *Vishvavallabha* (Dear to the World: The Science of Plant Life) by Chakrapani Mishra (1577 CE) in Sanskrit (Sadhale, 2004). These texts deal with agriculture, horticulture, and fauna.

***Kunapajala*–the world's first fermented liquid fertilizer.** Almost all texts on *Vrikshayurveda* (from 800 CE through mid-1900 CE) strongly prescribe preparation of *Kunapajala*, which has been called the organic liquid manure of antiquity (Nene, 2000). It was originally prepared from waste materials: cooked and fermented animal flesh, marrow and fat mixed with cow dung and urine, topped with milk, curd, and ghee. Soil around trees and bushes was drenched which promoted excellent growth and yield (Sadhale, 1996). The descriptions of *Kunapajala* given by different authors are almost similar to that given by Surapala and thus its preparation allows

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considerable flexibility to farmers in choosing constituents and their proportions, and also in the procedure. However, preparation and use of *Kunapajala* had been virtually forgotten until AAHF published the English translation of *Vrikshayurveda* by Surapala (Sadhale, 1996). Even after its publication and description of *Kunapajala,* hardly any agricultural scientist took any interest in understanding and experimenting with it till Valmiki Sreenivasa Ayangarya who first published a short note "Herbal *Kunapa*" in 2004 (Ayangarya, 2004). He called it *Sasyagavya*. Later, an Herbal *Kunapajala* was described by Nene (2012), which is now commonly used by farmers. Comparison of *Kunapajala* with other similar products has also been made (Nene, 2018b).

Changes in Indian agriculture over time. Agriculture in India since ancient times evolved gradually in a natural way and farmers in these regions had developed some of the most sustainable management technologies for different agro-ecoregions. This was amply indicated by the ancient and medieval texts on agriculture through their valuable information on agriculture. It was through this type of agriculture that populations were provided with general food security for several millennia with the exception of the occasional famines in a few limited pockets due to droughts. Importantly, its main fabric was never disrupted in spite of the outside invaders except during the British-Rule.

However, it was from 1600-1900 CE that major changes took place in farming systems in India mechanization, plant and animal exploration, introduction of crops and animals in new areas (Nene, 2018a). This brought in the domination of European agricultural systems over the indigenous methods, and with the USA joining, animal power was replaced with the fuel power. Progress was made in developing chemical fertilizers, and awareness of plant protection, which existed in ancient India, increased in the West.

It was during 1900-1947 CE that tractor- and animal-drawn farm implements and chemical fertilizers and pesticides were introduced in India. Thus, traditional Indian agricultural practices were ignored, and European practices were

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taught and introduced by the British Rule thus effecting drastic changes in Indian agriculture.

During 1947-2000 CE, Indian agriculture made a rapid progress in creating institutions and training of scientific staff (Nene, 2018a). The first agricultural university was established in 1960 at Pantnagar (Uttarakhand) followed by in all other states. The Indian Agricultural Research Institute (IARI) at Delhi was greatly strengthened, and so was the Indian Council of Agricultural Research (ICAR). Countrywide networks for research on crops and animals were established. These efforts resulted in the availability of improved and high-yielding wheat and rice varieties to farmers. Emphasis on fertilizer and pesticide production was greatly increased. This ushered in the era of "Green Revolution".

Present status of Indian agriculture

Broadly, the operational land holdings in India belong to small (<1 ha), medium (1-4 ha), and large (4-10 ha) categories with 125.86 million, 19.3 million and 0.83 million farmers in the three categories, respectively (Krishnan, 2018). Of these, the small and marginal holdings constituted 86.21% of the total land holdings and registered a marginal (7.34%) increase whereas the medium and the large holdings showed 2.13% and 15.31% decrease, respectively, in 2015-16 compared to 2010-11, according to the tenth agricultural census. It is this group of farmers who mostly followed traditional agriculture practices in the past, but now use improved seeds and at times excessively chemical fertilizers for soil fertility, and pesticides for controlling diseases, insect-pests and weeds, and only some of them use farmyard manure for maintaining soil fertility. However, it is the medium- and large-holder farmers because of their better affordability that they generally use excessive chemical fertilizers and pesticides without much regard to their disastrous ill-effects. Such indiscriminate use combined with mono-cropping but without crop rotation and green manure culture has caused immense damage to environment (soil degradation and pollution, and water pollution) and human health, and continues to do so. It is a system failure that has been occurring since the start of the Green-Revolution, and it is only lately that some awakening has been created by the government and the non-governmental organizations (NGOs) among the farmers, administrators, politicians, and the public.

Challenges presently faced by Indian agriculture. As indicated above, India is now proudly self-reliant in grain production, thanks to the Green Revolution. However, there has been a price tag for this achievement as in the enthusiasm to increase production we faulted in paying the required sufficient

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attention to the ill-effects of the use of the market-driven high-input technology. Thus, the present-day agriculture in India has been in many ways drastically changed compared with the past.

From "traditional" to "modern" farming. Drastically, Indian farming has changed - from "Traditional" to "Modern". It has now become highly intensive and high-input with excessive use of fertilizers and pesticides with little use of farmyard manure, and no or only a little concern to the environment and human health. Areas where small-holder farmers used high inputs without regard for affordability have faced disastrous ill-effects and could not resist the market forces, and thus subsequently quitting/migrating from the farming enterprise. Similarly, modernization of agriculture and introduction of new crops in farming systems have also caused disastrous results. Introduction of Bt cotton in Vidharbha region of Maharashtra state replacing the traditional crops in the cropping systems proved disastrous and resulted in crop failure due to drought and farmers' suicides is one example to highlight it (Beniwal, personal observation).

From traditional "multi-cropping" to "mono-cropping". There is a drastic change observed in farming systems, from multi-cropping to mono-cropping, compared with our traditional multi-cropping farming systems, and has thus caused problems for farmers, especially for small-holders. Thus, the inbuilt mechanism of shock absorbing capacity of the multi-cropping to withstand the losses due to the failure of one crop in the system which would not make the farmers suffer much compared with the mono-cropping situation. Another consequence of this change is the well-recognized inherent danger of buildup of excessive pests and diseases that could destroy a particular crop in mono-cropped situations. Similarly, the advantages of the buildup and presence of different types of useful soil microbes in a multi-cropping situation are lost in a mono-crop situation. It certainly could be considered as degradation of soil's natural strength, or in other words, its natural immune system,

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which helps in maintaining its productivity.

Soil and human health issues. The intensive and high-input agriculture is now facing new challenges like soil and environmental damage and ill-effects on the human health. As a result, the mother soil has been damaged and very badly polluted with the excessive and indiscriminate use of chemical fertilizers and pesticides (herbicides, insecticides and fungicides). As a consequence of these and non-addition of farm-yard-manure (FYM) the soil has been slowly deprived of its much-needed and vital organic matter responsible for maintaining the pulverizing nature of soil and its productivity. Another ill-effect of the combined use of fertilizers and pesticides has been the pollution of the underground water, which in some areas has been rendered undrinkable and unusable. Moreover, the excessive use of plant protection chemicals has rendered the vegetables and fruits unsafe for human consumption, and thus has been silently and adversely affecting human health.

Failing crop economics. In conclusion, the trade-off has been costly, and as a result, agriculture in India is now on the cross-roads and facing new challenges that have arisen out of intensive, high-input, market-driven, and mono-cropped agriculture. The increased cost of inputs has increased the cost of production resulting in the decline of net crop returns over the years; thus making their use cost-ineffective and unsustainable. This coupled with crop failure(s) has caused unnecessary troubles and unbearable losses for the farmers resulting at times ultimately in the loss of their lives. All these undesirable and unwanted changes put together are what are referred to as the "ill-effects" of the Green Revolution endangering the Indian agriculture. In fact, the safe nature, eco-friendliness and sustainability of such a deteriorating agriculture system, especially for the marginal, resource-poor and small-holder farmers, is now being questioned in India as well as globally. As a result, now there is a talk of Ever-green Revolution in Indian agriculture. Considering the challenges of meeting the SDGs 2030, it is time to review this situation to work out corrective ways to prevent further deterioration of Indian agriculture and improve it to make it safe, eco-friendly and sustainable.

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Need for action and possible options

The problems being encountered in the present-day Indian agriculture as highlighted above need to be addressed. Ignoring and not doing anything about it and letting the situation continue at this stage may have more serious implications in future. Thus, it is imperative that we must act now and take appropriate actions to stop the ongoing onslaught to Indian agriculture and to make it safer, eco-friendly and sustainable, and at the same time profitable. India has had a rich agricultural heritage and agriculture was the main industry of the ancient Hindus (source: *Rigveda)*. Interestingly, most of the small-holder farmers still like to follow some of the traditional farming practices, inventory of which has been compiled by the Indian Council of Agricultural Research (ICAR) (Das *et al.*, 2002; Das *et al.*, 2003a; 2003b). We at AAHF also strongly believe that there is a great deal to learn from the traditional wisdom and the indigenous time-tested agriculture technologies that have sustained the Indian agriculture and farmers over several millennia in the past. Therefore, their suitability for ensuring eco-friendliness and sustainability of the present-day agriculture must be considered.

The value of India's past agriculture knowledge

As indicated earlier, India has had a rich agricultural heritage since the time of *Rigveda* (c. 8000 BCE) (Randhawa, 1980; Nene, 2007, 2012a, 2018a;). The agriculture in India evolved in a natural way with development of traditional management technologies that provided it sustainability over a long period of time. The AAHF, through the ground breaking works of late Dr YL Nene unearthed the ancient and medieval history of Indian agriculture, which made us understand the rich agricultural heritage of India (Nene, 2018a). The history of ancient and medieval agriculture practices and its genesis from the ancient times, which has been accurately traced, compiled and translated by AAHF, serves as the major and important source of information that has successfully laid a good foundation of modem organic farming in India due to their elaborate documentation in the annals of literature. In addition, AAHF also started a quarterly international journal on Asian Agri-History in 1997, which has so far well served the dissemination of agricultural heritage of South and Southeast Asia.

Many of the ancient and medieval agricultural practices are even now followed in many different countries including India, although only partially (Das *et al.*, 2002; Das *et al.,* 2003a, 2003b; Das *et al.*, 2004a). History and evolution of organic farming can be truly traced to India as it is an ancient and oldest form of civilization with rich agriculture tradition and heritage.

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Scope of the use of *Vrikshayurveda* and traditional practices for sustainable agriculture

Vrikshayurveda and traditional practices have tremendous relevance and potential for their use in the sustainable agriculture based on their demonstrated use in the sustainability of the ancient and medieval Indian agriculture. The valuable information from books −*Krishi-Parashara* of Parashara, and *Vrikshayurveda* of Surapala −can certainly be very useful in sustainable agriculture as they describe traditional agricultural practices useful for agriculture by maintaining soil productivity together with the fermented liquid fertilizer *Kunapajala*, which promotes excellent plant growth and yield and also simultaneously protects plants from pests and diseases, and was strongly prescribed by almost all texts on *Vrikshayurveda* (from 8000 CE through mid-1,900 CE). *Kunapajala*, considered a liquid manure of antiquity and containing most of the macro (N, P, K, Ca and Mg) and micro (Zn, Cu, Fe, and Mn) elements can be easily prepared by farmers (Nene, 2000).

Validation of the usefulness of *Kunapajala* in India. Although *Kunapajala*, described 1,000 years ago, its identity and usefulness became known only since 1996 (Sadhale, 1996) and its vegetarian (herbal) versions are known since 2004 (Ayangarya, 2004) and 2012 (Nene, 2012b), however, it was only slowly that agricultural scientists in India realized its usefulness, and thus were slow to use and demonstrate its usefulness for a large-scale use.

The use of *Vrikshayurveda* practices in tea cultivation was well demonstrated and documented in Abali Tea Estate, Abali village of Arunachal Pradesh (Ayangarya, 2006). Application of *Sasyagavya* to soil resulted in increased organic content and nutrition, and thus healthy tea plants. Use of *Kunapajala* and other Vrikshayurveda products at the tea estate, while maintaining soil and tea plant productivity, led to chemical residue-free tea, which clearly pointed to a remarkable advantage of *Kunapajala* over the current usage of chemical fertilizers and pesticides. This was in terms of maintaining soil and tea plant productivity. As a result, large-scale adoption of *Vrikshayurveda* practices occurred in tea production in many tea estates of the Darjeeling area of West Bengal which were of great consequence as about two-third of the tea gardens became organic tea producers in the

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region (Parmar, 2009; 2017); a great achievement by every standard.

Presently, Padma Shri Subhash Palekar, who through preparations like *Jeevamrit*, based on fresh cow dung and urine and other constituents after their partial fermentation, has demonstrated its nutritional value by the overall enhancement of crop productivity and better economic returns for farmers and resource conservation through what he calls as the Zero Budget Farming (Palekar, 2005). It is generally accepted that plant roots utilize chemical fertilizers faster than organic manures especially when the soft and dry organic manures are scattered in the field. Herbal *Kunapajala* and its applications are very different from the application of other organic manures as the former is a liquid and therefore ready to reach the root zone in a short time. Secondly, the ingredients of Herbal *Kunapajala* are fully fermented, which means the mass (proteins, fats, etc.) is already broken down into simple low molecular weight products, and nutrients, which would become available to plants faster than from the traditionally applied organic matter (Neff *et al*., 2003).

Use of cowdung and cow dung-based decomposed manure. The use of cow dung directly for crop production is found in *Rigveda* and ancient epic Ramayana. Parashara in his book mentions the use of cow dung in agriculture (Sadhale, 1999). He recommended that the powder of the sun-dried cowdung cakes should be stored in a pit in the field and taken out as manure at the time of sowing. He emphasized that crops grown without manure would not give yield. Evidences in *Vishvavallabha* by Sri Chakrapani Mishra (1577 CE) (Sadhale, 2004) and *Nuksha Dar Fanni-Falahat* by Mughal Prince Dara Shikoh (son of Shah Jahan) (1650 CE) (Sadhale, 2000) also suggest that animal dung was directly applied to the crops. The latter also mentioned the use of dung of pigs, besides dung of other animals.

During his stay in India between 1900 and 1940, Albert Howard had suggested the use of dung-based decomposed manure (Howard, 1940). Interestingly, no report on the use of decomposed manure is available for its use in India in the early ages till probably the late 17th century, and the dung was directly incorporated in the fields (Joshi, 2012). The literature is indeed obscure as to when the decomposed manure was prepared and used in the form of FYM in India as no mention of its use is found from the Moghul period till early 1900s.

It is not found in the report of Lord Wellesley in 1805 submitted to the Court of Directors of East India Company on the study of agriculture in India, the survey report by Francis Buchanan in 1801 covering Madras and Malabar regions, and the report of Famine Commission of 1880 by JA Voelcker (Katyal and Lal, 2005). However, it is advisable to use FYM for maintaining the organic matter content and humus of the soil, the key to soil fertility and productivity by promoting biological activities. Otherwise, soil fertility and productivity would further deplete creating soil health problems, non conducive to achieving increased agricultural production (Chandra, 2005).

Use of earthworm-inhabited soil. The earliest historical evidence on the use of earthworm inhabited in soil is mentioned in *Kashyapiyakrishisukti* (c. 800 CE) in which saint Kashyapa described the presence of earthworm as desirable character of good soil (Katyal and Lal, 2005). Although earthworms must have been part of the ancient agriculture, no other evidence is found in available literature about preparation of man-made Vermicompost. But, over generations, it is well experienced that earthworms due to their constant movement in the soil can create loose and friable soil besides increasing soil aeration and infiltration rate. However, it is only in the last 25-30 years that a technique to prepare Vermicompost manure by using imported species of earthworm, known as *Eisenia foetida*, which is only a surface feeder and does not eat soil and does not go into the soil, was developed and popularized. However, this ex-situ preparation of Vermicompost raised the cost of cultivation more than the inorganic or integrated farming. The use of *Jeevamrit* is found to naturally increase earthworm populations in soil (Palekar, 2005) and also similarly by Herbal *Kunapajala* (Parmar, personal communication).

Use of green manure. Use of green manure crops is another good way of providing organic matter to the soil (Chandra, 2005). Moreover, they provide additional nitrogen and protective action against erosion and leaching. The practice has high relevance to the concept of present-day sustainable agriculture.

Use of traditional practices of agriculture. The traditional practices which are being presently followed throughout India have been documented by the Indian Council of Agricultural Research (ICAR) (Das *et al.*, 2002; Das *et al.,* 2003a; 2003b; Das *et al.*, 2004a) and also have been described in books (Palekar, 2005) and a number of articles published in journals. Interestingly, many of these current practices, which have ancient/medieval origin, have been validated as supported by the documents of ICAR (Das *et al*., 2004b), Centre for Indian Knowledge Systems (CIKS),

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Tamil Nadu (Balasubramanian, 2019), and by the validation work carried out so far by AAHF and its collaborators on tea (Ayangara, 2006; Parmar, 2009; 2017), tomato (Deshmukh *et al.,* 2012), and other independent workers in organic farms (Narayanan, 2006), on damping off of tomato (Hooda *et al.*, 2011), and on growth and development of paddy (Misra, 2007).

The above narrative shows that the time-tested practices from ancient and medieval times and *Vrikshayurveda* have tremendous relevance and potential for use in the present-day agriculture. Thus, they are considered as the best option. Their usefulness has been demonstrated by encouraging results of the validation work carried out by AAHF, Palekar's Zero Budget Farming, and Jaivik Kheti of Tara Chand Belji of Madhya Pradesh State, and others.

Sustainable Development Goals

The rampant challenges of poverty, inequality and climate change voices around the world demanded the world leadership for action to alleviate their effects. To turn these demands into actions, world leaders gathered on 25 September, 2015 at the United Nations (UN) in New York and the UN General Assembly adopted the 2030 Agenda for Sustainable Development. Building on the principle of "leaving no one behind", new agenda emphasizes a holistic approach to achieving sustainable development for all. The 2030 Agenda includes 17 Sustainable Development Goals (SDGs), which will guide policy and funding to transform our world for the next 15 years, beginning with a historic pledge to end world poverty. These 17 SDGs include: 1, no poverty; 2, zero hunger; 3, good health and well-being; 4, quality education; 5, gender equality; 6, clean water and sanitation; 7, affordable and clean energy; 8, decent work and economic growth; 9, industry, innovation and infrastructure; 10, reduced inequality; 11, sustainable cities and communities; 12, responsible consumption and production; 13, climate action; 14, life below water; 15, life on land; 16, peace and justice strong institutions, and 17, partnerships to achieve the goal. It may be relevant to mention here that the concept of the SDGs was born at the UN Conference on Sustainable Development, Rio+20, in 2012 with the objective to produce a set of universally applicable goals that would balance the three dimensions of sustainable development, i.e., environmental, social, and economic.

It may also be mentioned here that the American National Library took up the

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task of tracing the history as a part of documentation on sustainable agriculture while finalizing the protocols for the present methods of organic farming. For this, the ancient publications were traced from the 1st century BCE till 1979, and the results were documented. However, this attempt could not include any information on the time-tested historical evidences of agricultural sustainability of the Indian, Chinese, and Mesopotamian civilizations and also of pre-Christian and Christian era, possibly due to untraceability of documents/ scripts/proofs of the reports from these civilizations as many of these documents were in vernacular/local languages other than the English. This happened as virtually no original texts on agriculture from ancient/medieval periods of Bharatvarsh were available and it was only possible in 1996 after the AAHF was established in 1994 to unearth the ancient and medieval Asian agricultural literature in Sanskrit and had them translated to English language to facilitate their dissemination to Asian and International agricultural community to promote research on sustainable agriculture in the South and Southeast Asia regions.

Meeting Sustainable Development Goals through Sustainable Agriculture

As highlighted earlier, a sustainable agriculture would consist of the development of a desirable low-input agriculture which could sustain the production of safer farm products for human consumption either without any use or a very judicious use of only safer pesticides to control pests and diseases, be eco-friendly by conserving the traditional multi-cropping system, productivity of mother soil by maintaining its organic matter, preventing soil and sub-soil water pollution, and above all, making present-day agriculture affordable and economical. Sustainable agriculture is feasible if the farmers would follow time-tested *Vrikshayurveda* and traditional practices in their farming rather than the modern high-input intensive agriculture which they have been so far following since the Green Revolution. Development of such a sustainable agriculture, which is feasible, would help to meet a number of the Sustainable Development Goals (SDGs). Such a

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situation would help to achieve nine out of 17 SDGs, wholly or partly. These include: poverty elimination (SDG1), zero hunger (SDG2), good health and wellbeing through good nutrition (part of SDG3), contributing to economic growth (part of SDG8), reduced inequalities (SDG10), sustainable village communities and cities through reduced migration to cities (part of SDG11), strengthen climate action (SDG13), life on land (SDG15), and contribute to partnerships (SDG17).

Actions required

Considering the relevance and potential of *Vrikshayurveda* practices in sustainable agriculture and its role in meeting the SDGs as discussed above it would be important to harness their advantages. For this, two things would be required to be done: (i) need for a paradigm shift in management of agriculture, and (ii) need for a policy shift in agricultural research and development at the country level.

Need for a paradigm shift in management of agriculture

There would be a need to change the ways the agriculture would be managed. These would vary according to the size of farmer holdings, namely, small-holder, medium-holder and large-holder farmers.

For small-holder farmers. These farmers would need to make a shift from the present high input market-led technology to eco-friendly lower input *Vrikshayurveda* and traditional practices. They would need to lay greater emphasis on traditional, multi- and mixed-cropping and on raising animals on the farm as in the past (for making FYM, and use of dung and urine for making Herbal *Kunapjala* or other liquid bioproducts for use in agriculture). Herbal Kunapajala of AAHF has a distinct advantage over others as it is the only one which also serves as a bioinsecticide and biofungicide, protects crops from light frost and drought situations, and bring favourable changes in crop weed flora. Research emphasis would be on clear and detailed understanding of problems of such farmers and providing solutions to their problems and to the cropping systems. It would be required to provide all the necessary guidance (through the research and development machinery) useful for agriculture sustainability of small-holder farmers and their welfare

that too on a war footing. Such a sustainable agriculture for them could also be termed as "welfare agriculture".

For medium- and large-scale farmers.

For these group of farmers an integrated approach with a blend of the modern technology with traditional and *Vrikshayurveda* practices would be suitable. This would need education, emphasis, awakening and encouragement of farmers on the need of the reduced and judicious use of chemical fertilizers and increased use of organic and green manures. They would also need to either avoid or reduce the use of harmful chemicals for diseases, pests and weed control and go for safer pesticides. Attempt should be to make their agriculture economical, eco-friendly (improved soil nourishment through organic matter enrichment and use of Herbal *Kunapajala* resulting in less soil degradation), and with improved sustainability.

Need for a policy shift in agricultural research and development at the country level

In order to ensure use of the *Vrikshayurveda* and traditional practices by farmers there certainly would be a need to support and strengthen research on them. For this, the agenda for a policy shift in agriculture education, research and development at the country level would need to be strengthened. These areas would need to form an integral part of agriculture research in the country. This would mean that research on *Vrikshayurveda* and traditional practices would be made an integral part of the agricultural research in the state and central agricultural universities (SAUs and CAUs) and ICAR's research institutions, and would be supported with sufficient funds. Also, there would be an urgent need to strengthen their validation work through large-scale on-station and on-farm research by SAUs, CAUs and ICAR research institutions, and Krishi Vigyan Kendras (KVKs).

There are so many other ways, procedures/agricultural practices or wealth of knowledge mentioned in our ancient agriculture literature regarding agriculture, plant nutrition and protection and allied areas which need to be unveiled by including them in the syllabus of undergraduate and post-graduation degree programme. Agenda of R&D on *Vrikshayurveda*-based traditional practices is the need of hour and must form an integral part of agriculture education and research in the country. In order to bring them into the main stream of agricultural education they would need to be included in the academic curricula of SAUs, CAUs and ICAR research institutions. With great efforts from late Dr YL Nene, a course on agricultural heritage of India was included in all the SAUs starting the 2016-17 academic session. Now, there would be an urgent need to modify our academic curricula in order to include a sufficient number of courses to ensure the required emphasis on *Vrikshayurveda* and traditional practices. In the same context, it would be very much in line to introduce the subject of *Vrikshayurveda* at the Intermediate

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School level. Going a step further, it would be desirable to establish a Department of *Vrikshayurveda* and Traditional Agriculture in each agricultural university in the country as done already by Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu. These above actions would need to be taken urgently and on a war-footing to ensure achievement of several of the SDGs 2030.

Need to create quick and greater awakening among all the stakeholders

An attempt by the joint efforts of AAHF and the tea gardens starting in 2004 in Arunachal Pradesh and in 2008 in the Darjeeling area had led to successful use of these *Vrikshayurveda* practices in Arunachal Pradesh and Darjeeling tea gardens. This was possible by evaluation and validification of these practices. In order to make these practices popular and accessible to farmers in the country a greater awakening certainly would need to be quickly created among all the stakeholders of agriculture. These would include all the farming communities, agriculture researchers, agriculture research and education managers and administrators, politicians and industry. Here again, a much greater role by agricultural institutions is envisaged.

Conclusion

Importance of agriculture in the country makes it vital to take urgent steps to ensure an eco-friendly and sustainable agriculture of small-, medium- and large-scale farmers. For this, the best option is to use the time-tested *Vrikshayurveda* and traditional practices for small-scale farmers, whereas a mix of these together with modern agricultural practices for medium- and large-scale farmers. *Kunapajala*, the first organic liquid fermented fertilizer described in India in *Vrikshayurveda* book by Surapala (c. 1000 CE) and its modified vegetarian version, Herbal *Kunapajala* has tremendous qualities and uses and relevance and potential for sustainable agriculture as has already been demonstrated through the work of AAHF in tea in West Bengal and Arunachal Pradesh, and in different crops in Kerala and other states of the country. Indian

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agricultural scientists have an unprecedented opportunity to work on the efficacy, utilization, and biological interactions of Herbal *Kunapajala* and its application to sustainable agriculture in India. If we do not do it ourselves then our foreign counterparts would take this initiative, and as has been customary in the past, we would have to then follow them.

There is a need to support and strengthen research in order to encourage the use of *Vrikshayurveda* and traditional practices. For this, a policy shift in agriculture education, research and development at the country level would be required. The education and research on *Vrikshayurveda* and traditional practices need to be made a part of the national agricultural education and research agenda.

Actions on a war footing are urgently required at education, research, development and technology transfer stages. There is an urgent need to create awakening among all the stake-holders of agriculture about the ill-effects of the modern technology and the advantages of the *Vrikshayurveda* and traditional practices for sustainable and eco-friendly agriculture. It surely will help to achieve several of the SDGs of 2030.

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