CURRENT SCIENCE

Volume 114 Number 8 **25 April 2018**

EDITORIAL

Science for sustainable agriculture to achieve UN SDG Goal 2

From the beginning of 2018, UN Sustainable Development Goals (SDGs) have become priority areas needing international and national attention and action. There are 17 goals, of which goal no. 2 reads as follows 'End hunger, achieve food security and improved nutrition and promote sustainable agriculture'. These goals are exceedingly important for our country in view of the widespread prevalence of undernutrition and malnutrition. Therefore, we should develop a scientific and social strategy to achieve these goals.

Hunger has five major dimensions. The first relates to undernutrition which can be solved by effective implementation of the National Food Security Act (2013) which commits the provision of adequate calories to all the Indians needing social support to end hunger. The second aspect relates to protein hunger. This again can be overcome through greater production and consumption of pulses, poultry and fish products and horticulture. Peri-urban horticulture can make an important contribution to solving the problem of protein hunger. The third aspect of hunger relates to micronutrient deficiencies like vitamin A, vitamin B12, iron, iodine, etc. This can be overcome by establishing genetic gardens of biofortified plants. The fourth area relates to clean drinking water, sanitation and primary healthcare. In this area there is need for community organizations which can work with the concerned government agencies. Finally, the area needing attention is imparting nutrition literacy through a community hunger fighter's programme. If we have to achieve the aims of SDG-2 in the field of overcoming malnutrition and hunger, we should initiate without further delay the above 5-point programme.

Technologies for enhancing availability have been largely based on increasing productivity through Mendelian breeding (pure line selection, hybridization and selection and exploitation of hybrid vigour). During the middle of 20th century colchicine-induced polyploidy breeding and induced mutation breeding were introduced. Polyploidy breeding has been of limited success. Autotriploids ($2n = 3x$) in certain fruit crops (e.g. water melon, grapes, guava, etc.) have been induced to obtain bigger fruits with no or fewer seeds. Autotriploids also had higher content of nutrients. The first anthropogenic creation of an artificial allopolyploid was *Triticale* in 1875. This is hybrid of rye (*Secale cereale* ($2n = 14$)) and *T. durum* ($2n = 4x = 28$). The triticale has an evolutionary history of about 140 years. The allohexaploid triticale ($2n = 6x = 42$) had initial problems of severe meiotic irregularies and sterility. These have been largely overcome and now about three million hectare of triticale are grown in certain forms of marginal soil, drought-prone regions of North Africa and in cold regions with sandy soil (Scandinavian regions). The UN FAO Plant Production and Protection Paper Number 179 (2004) elaborates these aspects. Among the various technologies based on predominance of natural evolutionary mechanisms, the induced mutation breeding using X-rays and gamma rays as well as an alkylating agent, ethyl methanesulphonate (EMS), is clearly the most sustainable from ecological, social and economic points of view. This statement is substantiated by the declaration that 'mutation induction coupled with selection remains the cleanest and most inexpensive way to create new varieties by changing single characters without affecting the overall phenotype'. As of today, mutation breeding throughout the world has led to official release of more than 3200 mutant varieties from more than 200 plant species, in more than 70 countries (http://www.fao.org/ag/portal/age/age-news/detail/en/c/269620/). The new traits induced comprise resistance to a variety of abiotic and biotic stresses, neutrality to day-length (i.e. photoperiodism), etc. which are now highly relevant to evolve climate-resilient crop varieties in the current epoch Anthropocene.

The genetic engineering of crop plants, as of now, mostly consists of *Bt* (Cry proteins) to provide resistance against borer pests and Ht (herbicide tolerant) cotton, corn and soybean. Experience over three decades has shown that pests develop resistance sooner than later. This results in farmers having to resort to the application of high levels of pesticides defeating the very purpose of developing these transgenic crops. Further, many herbicides such as glyphosate used in making the 'Round Up Ready' Ht transgenics and glufosinate have been shown as genotoxins. In India, the *Bt* trait has been introduced into hybrid tetraploid cotton which requires not only expensive inputs but also denies the farmers the saving of seeds for subsequent cultivation. Resource-poor marginal farmers find it very difficult to buy seeds for sowing every time from developers at high costs and also incur high costs of cultivation. The transgenic herbicide-tolerant crops induce resistant 'Super Weeds' (https://www.sheffield.ac.uk/news/nr/evolution-of-herbicide-resistance-1.763603?utm-source=twitter). It is for these reasons that genetic engineering, as of now, is not a sustainable technology. Recently, the collapse of 'bollgard II' cotton with the development of resistance by pink boll worm has led to a desperate plea to cotton farmers to adopt Integrated Pest Management (IPM) to sustain Bollgard II (Komarlingam, M. S., *Curr. Sci*., 2017, **112**(10), 1988–1989). This is an example of an inexpensive traditional technology sought after to the rescue of an expensive and sophisticated but failing technology.

What have been aforementioned lead to the question as to the attributes of technologies which are conducive to promote sustainable agriculture (SDG number 2). It should also be kept in view that the planet Earth is in epoch Anthropocene with major alterations in planetary level functions (e.g. nitrogen cycle, carbon cycle, hydrologic cycle, etc.). Global warming-driven climate change with its several ramifications (e.g. sea level rise, increase in day and night temperatures, more frequent extreme hydrometeorological events, etc.) would adversely impact agriculture. The fact that nitrogen cycle has been badly vitiated with more nitrates accumulating on land and aquifers than being reconverted into nitrogen in the atmosphere cautions against continued application of high levels of inorganic nitrogen fertilizers. With reference to global warming, it is generally agreed by climate scientists that with an increase of average global temperature of about 1.5°C, the 'tipping point' would occur. Humanity as of now has no clue whatsoever about its survival in a world with vastly altered seasons, monsoons, extreme hydro-meteorological events, natural cycles, etc. Therefore, a shift from chemical intensification to a 'sustainable intensification' of inputs with 'biological softwares' (i.e. biopesticides, bio-fertilizers) becomes highly relevant.

Development of technologies for sustainable agriculture needs to adopt the 5Es (i.e. ecology, economics, energy, employment (rural livelihoods) and equity). The reason for the diminution of effectiveness of Green Revolution of the 1960s is that it exerted harmful effects on soil, freshwater and biodiversity. The commodity-centric Green Revolution also failed to enhance rural livelihoods. The chemical intensification associated with Green Revolution led to steep increase in the incidence of cancers among farmers and their family members. The evergreen revolution eliminates all the negative aspects of Green Revolution and provides for on-farm and non-farm rural livelihoods by conservation and use of local natural resources. Training and capacity building for skill empowerment and knowledge empowerment through internet-based Lab-to-Land, Lab-to-Lab, Land-to-Lab and Land-to-Land linkages provided in the Village Knowledge Centres (VKCs) are vital and basic to the success of evergreen revolution. Varied forms of ecoagriculture are introduced for the farmers to choose on a 'bottom-up' basis. The 'System of Rice Intensification' (SRI) is a good example of ecoagriculture in the sense that the rice crops are able to grow well and yield better with greatly decreased irrigation and reduced application of chemical fertilizers and pesticides. In 2009, the Royal Society of London published an authoritative and balanced report entitled, 'Reaping the benefits: Science and sustainable intensification of global agriculture'. Examined very critically, this report has so much in common with evergreen revolution. Evergreen revolution that is ideally suited for resource-poor small and marginal family farm holders has been known to increase productivity (kg/ha) contrary to the general belief. An untenable notion was that ecoagriculture results in diminished productivity. This is not true. A very large study comprised the analysis of 286 projects in 57 countries. It was found that mean relative yield was 79% increased across a wide variety of systems and crop types (Pretty, J., *Philos. Trans. R. Soc. B* (*London*), 2008, **363**, 447–465). Yet, 'yield' (kg/ha) is not the sole foundation of sustainable agriculture; 'yield fatigue' associated with Green Revolution emphasizes that besides yield, the resilience of crop varieties to the impact of climate change is substantially important. In other words, the need of the hour is 'climate-resilient crops'.

Finally, the SDG-2 in Indian context should keep population on radar. It is emphasized that population growth rate, especially for India, needs to be viewed with deep concern and concerted action. The current population of about 1300 million is already too high, considering the rapid depletion of the natural resources, particularly land, water and biodiversity. Farming land is a shrinking resource and freshwater for irrigation is also highly limited. Further, the loss of biodiversity limits the possibility to develop 'climate-resilient crops' for the present and future.

As mentioned earlier, sustainable agriculture involves moving away from green revolution to evergreen revolution which can help to increase productivity in perpetuity without ecological harm. In order to ensure that agriculture provides necessary macro- and micronutrients, we should bring agriculture, nutrition and health into an integrated system of research and application. In doing so, ecotechnologies which also promote social and gender equities should be adopted. This is the pathway for achieving SDG-2.

M. S. Swaminathan
P. C. Kesavan*

M.S. Swaminathan Research Foundation,
III Cross, Taramani Institutional Area,
Chennai 600 113, India
*e-mail: pckesavan@mssrf.res.in