with other treatment modalities (remdesivir, tocilizumab and other antibiotics). Recently, the Council of Scientific and Industrial Research (CSIR) in collaboration with Cadila Pharmaceuticals (Ahmedabad, India) is planning to develop MIP-based immune modulator called Sepsivac to enhance innate immunity and to expedite the recovery of the patients of COVID-19 (ref. 7). With the approval from the Drug Controller General of India, CSIR is now initiating a randomized, blinded, two arms, active comparator-controlled clinical trial to evaluate the efficacy of the drug in greater detail against COVID-19 (ref. 8). As of now, several other studies are also in progress in India to evaluate the effectiveness of MIP against SARS-CoV-2.

In the present ongoing debate focusing on exploration of the future use of BCG vaccine in COVID-19, no formal conclusion is made except making assumptions from the current observation. BCG vaccination might confer additional protection against nSARs-CoV2 in COVID-19 disease as there seems a logical correlation between nations having an active BCG vaccination programme and reduced COVID-19 related death. Rigorous clinical trials and mechanistic details need to be elucidated to find the beneficial role of BCG vaccination in COVID-19 infection. Even then, there could be a spectrum of response due to genetic variation within the population as well as in the BCG stains, prior exposure to TB, etc. The protective role of BCG could be a standalone or in combination with other medications. More research is needed to investigate this possibility.

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Prospective of Indian agriculture: highly vulnerable to huge unproductivity and unsustainability

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With merely 2.4% arable land resources and 4% water resources[1], Indian agriculture is feeding nearly 1.3 billion people, which implicates huge pressure on land and other natural resources for continuous productivity. Excessive use of chemical fertilizers and pesticides since the green revolution has increased crop productivity several folds, but the late phase of the green revolution has darker shades. Imbalanced and indiscriminate use of chemicals consequently resulted in detrimental impact on crop productivity and soil fertility[2,3]. Intensive cropping system involving injudicious use of fertilizers is the major culprit in deteriorating soil health and inducing secondary micronutrient deficiencies in the soil and nutrient immobilization in the soil and plants[4]. In such a scenario the soil microbial population is majorly impacted and we do not know how many microbial species have gone extinct or are in the endangered stage due to such agricultural practices[5]. In addition, such misuse of fertilizers is currently contaminating surface and underground water bodies through nitrate leaching[6], further causing serious health hazards to humans and animals. India achieved food security through the green revolution; however, we have gradually moved to an unsustainable agricultural system nationwide.

Balanced and judicious fertilizer application rates were used till mid 1960s; however, due to the green revolution inorganic fertilizer consumption increased tremendously and reached a maximum of 18.07 million tonnes (mt) of nutrients in 2000; from then on, the nation is facing a gradual decrease in growth and productivity. Similar amounts, viz. 16–18 mt of nutrients was incorporated in the soil year after year[7]. Most preferable cereal crops of India are wheat and rice, and it is evident from research that their cultivation mined huge quantity of nutrients from the soil. Recent studies showed that organic matter was depleted from nearly 3.7 M ha soil, and there was clear evidence for land degradation due to indiscriminate use of inorganic fertilizers and pesticide[8]. Intensive and continuous use of inorganic fertilizers is one major cause for depletion of soil organic matter (SOM) and consequently nutrient immobilization. Moreover, in India, in general, blanket fertilizer recommendations are followed for N, P and K which rarely match soil fertility needs. Secondary and micronutrients are also often ignored in different cropping systems. Many studies report that the use of inorganic fertilizers has a suppressive impact on SOM mineralization[9]. Soil carbon and nitrogen are indirectly linked biologically; quality and quantity of soil carbon improve soil microbial functions, abundance and diversity though impact of long-term fertilization on soil microorganism-mediated carbon mineralization is not studied extensively[10]. However, the crucial role of soil microbes on carbon mineralization cannot be denied. As most of the nutrients are immobilized in the soil and reduce soil nutrient release potential, Indian agriculture needs another revolution to attain maximum productivity without compromising on soil health. Therefore, in the present context, there is a need to strictly follow precision farming and evaluate the impact of integrated nutrient management system on soil physical chemical and, most importantly, biological properties.

The Economic Survey of India 2019–20 revealed that average annual growth rate in real terms in agriculture as well as its allied sectors has remained static in the last six years, which in turn is impacting farmers' income. The survey pointed out that agricultural productivity is being impacted by inefficient irrigation systems and degradation of soils following imbalanced chemical fertilizer application and imbalanced fertilization, thus increasing soil fatigue[11]. The fertilizer response ratio has also shown a declining trend, which is an indicator of responsiveness of soil fertility to fertilizer application. Thus, there is need to enhance fertilizer use efficiency significantly by enriching farmers' knowledge regarding the right product, dosage, time and method of application[11].

In the late green revolution period, research was more focused on enhancing productivity through the use of organic fertilizers[12], or a combination of organic and inorganic fertilizers[13]; however, limited studies focused on providing nutrients specifically and precisely to the crops. As nanotechnology is a new and emerging field of agriculture research, precise nutrients amendment to the soil through the application of nanomaterials is the utmost need to reverse nutrient immobilization and soil infertility[14]. More studies on evaluating the impact of nanomaterial-based fertilizers on soil nutrient availability, microbial functions and diversity, soil nitrogen and carbon ratio, and productivity are required in all developing nations to formulate efficient fertilizers and reduce the bulk application of inorganic fertilizers in the soil.

The declining fertilizer response ratio clearly indicates that fertilizer consumption is increasing with each year, but crop productivity is not increasing proportionately and is surprisingly stagnating. This is because most Krishi Vigyan Kendras[15], proximal centres for the farmers to get agriculture-related information, generally focus on only a few soil physical and chemical parameters and largely ignore soil biological aspects which are most crucial in the context of soil fertility. Consequently, questions regarding lower productivity by the farmers remain unanswered. Thus, there is a need for enhancing fertilizer use efficiency by providing a medium for precise fertilizer supply like nanomaterial to improve soil biological health, more specifically, soil microbial diversity.

Enhancing soil microbial diversity and subsequently microbial function is another major concern for Indian agriculture. Soil quality largely depends on soil microbes, as they mediate all the biogeochemical reactions[16]. Immediate community-level physiological profiling and phospholipid fatty acid analysis is required to understand the microbial functions and biological reasons for soil infertility[17]. Such testing will provide insights regarding biological function and with precise application of nutrients, we may able to reverse the trend of soil infertility. Gradual soil quality restoration can be attained through sustainable agriculture practices, more research on nanomaterials-based agriculture and not limiting such research to the greenhouse, and by understanding and unravelling the soil microbial functions and diversity.

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