Microbes and agriculture: potentials and gaps

An editorial on 'Beneficial microbes for sustainable agricultural production'[1] is highly relevant to underline a major gap in perspective and policy shift towards a safe food security and future agriculture. M. S. Swaminathan has realized that the high input and agro-chemical based agriculture is no more sustainable in the context of water, soil and food contamination and farmer's livelihood. He emphasized the need of evergreen agriculture; a food production system that is ecologically, socially and economically sustainable[2]. If we look at the emerging crisis of Indian food security and in the developing world, it can be counted as: (1) Fragmented and small land holdings with majority of farmers and peasants, (2) Ever decreasing agricultural income per head in spite of increasing input cost and inflations, (3) Increasing contaminations of water, milk, meat and plant produces due to frequent and indiscriminate use of fertilizers, pesticides, herbicides, etc., (4) Protein and vitamin malnutrition due to inadequate nutritive balance in food bowl and due to purchasing capabilities of productivity with pulses, oilcrops, vegetables, fruits, etc.

Agrochemicals have created distress in farmers, contamination in food items and malnutrition in children, women and aged. Microbes can be the backbone to rejuvenate the soil ecosystems, minimize the poison in food bowl and create a low input eco-friendly and cost effective food production system, which can create new small scale industries for the localized marketing and a hub for unskilled and semi-skilled labourers in rural and sub-urban areas.

Microbe-based industries can be operative in regional or local scale with low capital and less energy consumption, which can propagate, standardize and market microbial inocula with locally available organic carriers developed with use of cow-dung, vermi-compost and microbially digested agrowaste or organic plant-based gels and beads[3]. The Indian agricultural support network operates through National Agricultural Research System under Indian Council of Agricultural Research, its 101 research institutes and 71 agricultural universities. Further states in the federal structures operate through several state-controlled research and development-based institutions and departments under the various ministries. However, the country is unable to address issues of farmers suicides, their migration to cities and ecological, social and economic sustainability issues in agriculture and food security.

The Indian agriculture is one of the most vulnerable sectors to climate change and global warming and this new emerging threat will also impact the food bowl of mounting populations in the developing countries. A huge microbial diversity in the country's soil ecosystems is the big hope for future agricultural sustainability and food and nutritional security not only in India but in many highly populated developing countries with similar or warmer agro-climatic zones. Hence, we need to understand the gaps, challenges and potentials of microbial management and marketing of microbial products in agricultural and economic ecosystems.

It is estimated that macro life forms are about 1% of microbial resources and out of these rich tiny resources, only about 1% is known to us. Plant growth promoting rhizobacteria (PGPR) and plant growth promoting fungi (PGPF) which have been isolated and characterized as native or exotic strains, being free living or having symbiotic relationships with plants have shown enormous potential to be developed and used as biofertilizers and biopesticides. Many of them, e.g. strains of *Bacillus*, *Pseudomonal* and Trichoderma species have exhibited multiple PGPR or PGPF activities *in vitro* or on inoculation to the crop fields. Similarly, there are plenty of bacterial and fungal strains which have shown similar properties like nitrogen fixation, phosphate solubilization, siderophore production, production of IAA and as biocontrol agents for pests and pathogens[3].

A consortia of compatible microbes can provide more stability to the microbial stimulants during its storage and ecological succession in crop fields on application and can help plants to aquire N, P, K, Zn, Fe, IAA, etc. in an ecological way. The same microbial inoculants may control many pests and pathogens by its multiple mechanisms, can biodegrade toxic agro-chemicals in soil and can help in mitigation of green house gases (GHGs) caused warming by sequestration of CO_2, NO_x, etc. There are soil microbes which are methanogens and enhance methane production from agricultural soil, and there are methanotrophic soil microbes too which can consume and convert methane. If methanogens are there, we have to see, if methanotrophs can succeed over them in the agricultural fields.

There are plenty of microbial resources in the soil yet to be discovered, which may cause many beneficial impacts in the agro-ecosystems during the crop cultivation[4,5]. The stability of microbial consortia in commercial formulations and in crop fields may be better with the species diversity and species richness. The new generation organic carriers may also help in the stability and effectivity[6] of these microbial stimulants.

The zero budget farming and many other organic farming systems are based on use of native microbes only. However, the soil ecosystems have lost many of its native potential beneficial microbes. The exotic beneficial microbes with new properties can rejuvenate a new soil ecology which is required to enhance productivity of new crops in an ecological way. Studies on such ecological succession and establishment of new rhizospheric niche are required with native microbes, as well as native and exotic microbial inoculants.

1. Anandraj, M., *Curr. Sci.*, 2019, **116**(6), 875–876.
2. Kesavan, P. C. and Swaminathan, M. S., *Curr. Sci.*, 2018, **115**(10), 1876–1883.
3. Kavroulakis, N. *et al.*, *Rhizosphare*, 2018, **6**, 77–85.
4. Kumar, M. and Singh, R. P., *Clim. Change Env. Sust.*, 2018, **6**(1), 79–85.
5. Kawasaki, A. *et al.*, *PLoS ONE*, 2016, **11**(10), 1–25.
6. Kumar, S., Baudh, K., Barman, S. C. and Singh, R. P., *Ecol. Eng.*, 2014, **71**, 432–437.

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