



# Plant Soil

## Microbial Interactions

(Theory to Applications)

*Edited by*

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 Bharti

# 9

## Probiotics: A Review

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### INTRODUCTION

Probiotic is a type of good bacteria that help mankind in many ways, including fighting off bad bacteria when we have too much of it, helping us feel better.

The concept of probiotics is derived from human health science, where lactic acid bacteria and bifidobacterium species help in maintaining the intestinal gut system in a healthy condition (FAO/WHO, 2001, Hamilton-Moller *et al.*, 2003). The food/dairy products such as yogurt, cheese, pickles, sauerkraut, tsukemono, kimchi and fermented products utilize lactic acid bacteria and they help in improving the body's natural immune system and digestion and also increase lactose intolerance.

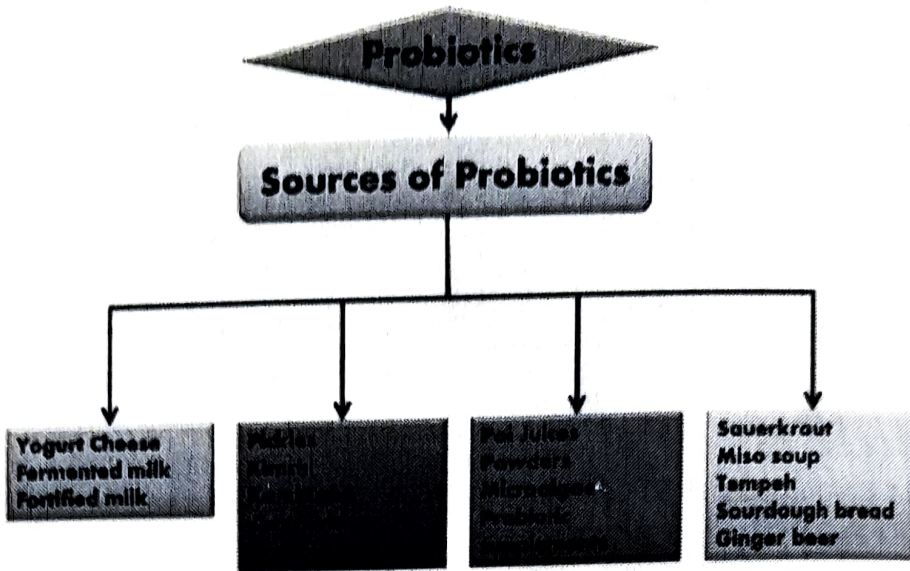
### WHAT IS PROBIOTIC?

The term probiotic is obtained from Greek language meaning "for life". The term was first described in 1965 as "substances secreted by one organism that stimulate the growth of another organism (Lilly and Stillwell, 1965). Today the term probiotics are defined as "live microorganisms" which confer health benefits on the host when administered in adequate quantity (Martin and Langella, 2019).

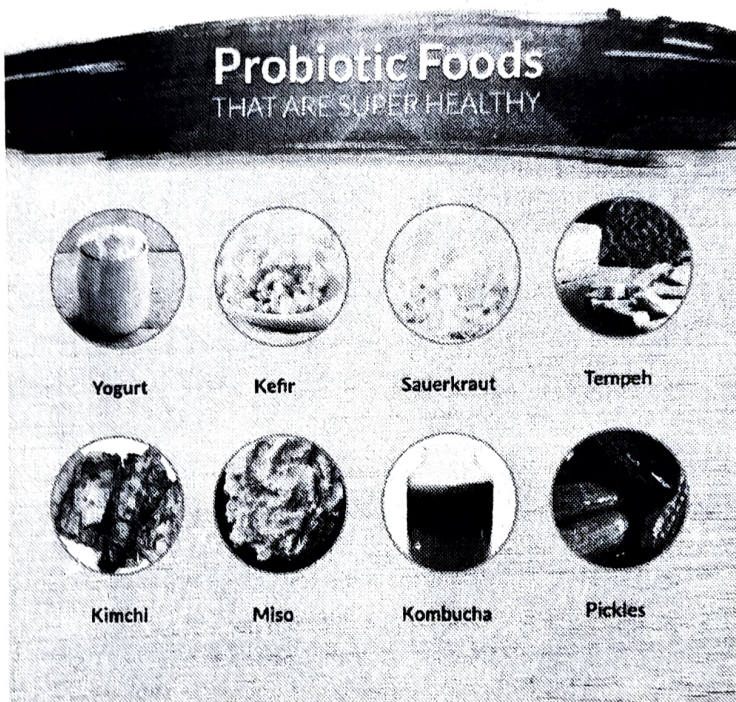
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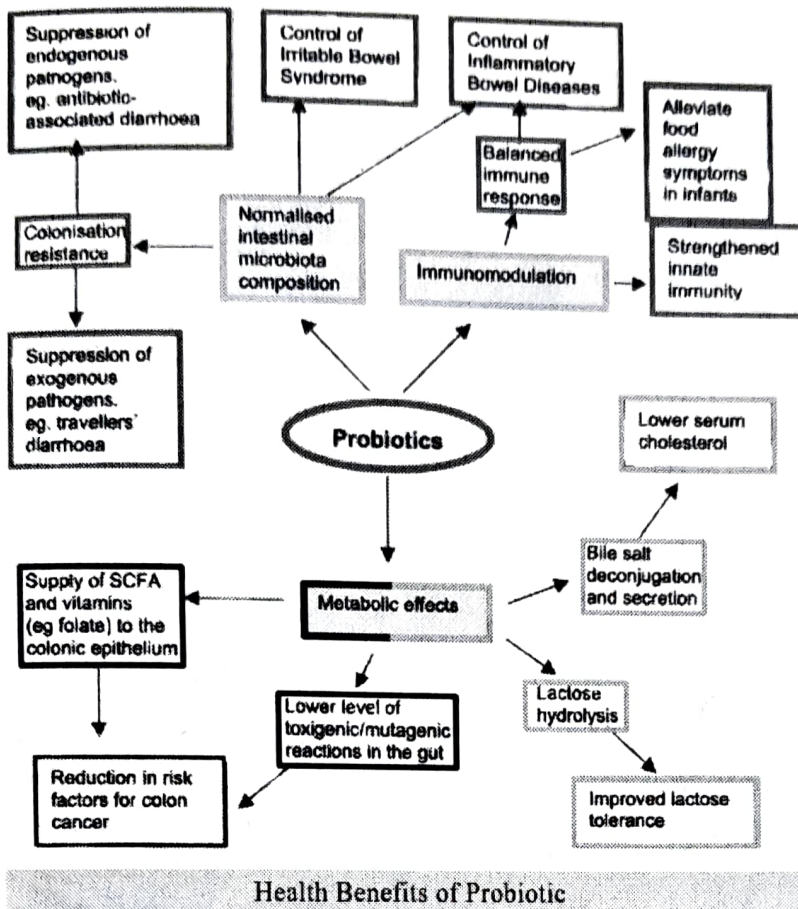
Sources of Probiotics (Courtesy: Creative Commons Images)



Probiotic foods (Courtesy: Creative Commons Images)

## THE BENEFITS OF PROBIOTICS

- Probiotics help in preventing or treating diarrhoea due to infections or antibiotics.
- Probiotics help to improve irritable bowel syndrome.
- Probiotics can boost the immune system.
- Probiotics can reduce inflammation and allergies.



## Health Benefits of Probiotics (Courtesy: Creative Commons Images)

Plant Probiotics are nothing but plant associated microorganisms that cause beneficial effects to the plant (Flores - Felix *et al.*, 2015; Spence *et al.*, 2015).

During the last two decades the interest in probiotic products has been increasing due to the Consumer's health awareness (Menrad, 2003).

The microorganisms used are lactic acid bacteria and bifidobacteria and even certain yeasts are used as probiotics.

### Four Popular Types of Probiotics

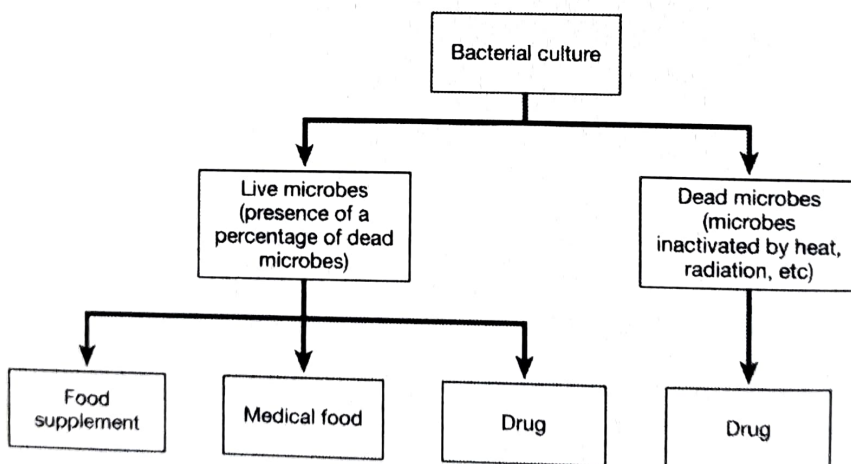
- *Lactobacillus acidophilus*. *Lactobacillus* is an anaerobic bacterium that produces lactic acid out of lactose and other sugars
- *L. casei*
- *Bifidobacterium bifidus*
- *Saccharomyces boulardii*

Probiotic consists of live micro organisms that provide health benefit to the host when administered in adequate quantity (FAO/WHO, 2001).

Current industrial probiotic food are mainly dairy products that could cause inconvenience due to the lactose and cholesterol content in it (Yoon *et al.*, 2006). However, development of fruit juice based functional beverages containing probiotics is of interest now-a-days due to their taste profile's that are appealing to all age groups. They also act as healthy and refreshing foods (Shechan *et al.*, 2007; Tuorila & Gardello, 2002). Plant probiotics are microorganisms that provide health benefits to plants when used in specific amounts (Islam & Hossain, 2012).

On the other hand, vegetable juices are also considered as ideal media for cultivating probiotic microorganisms (Luckow & Delahunty, 2004). Consuming tomatoes regularly reduces the risk of certain types of cancer (Weisburger John, 1998) and heart diseases (Pandey *et al.*, 1995).

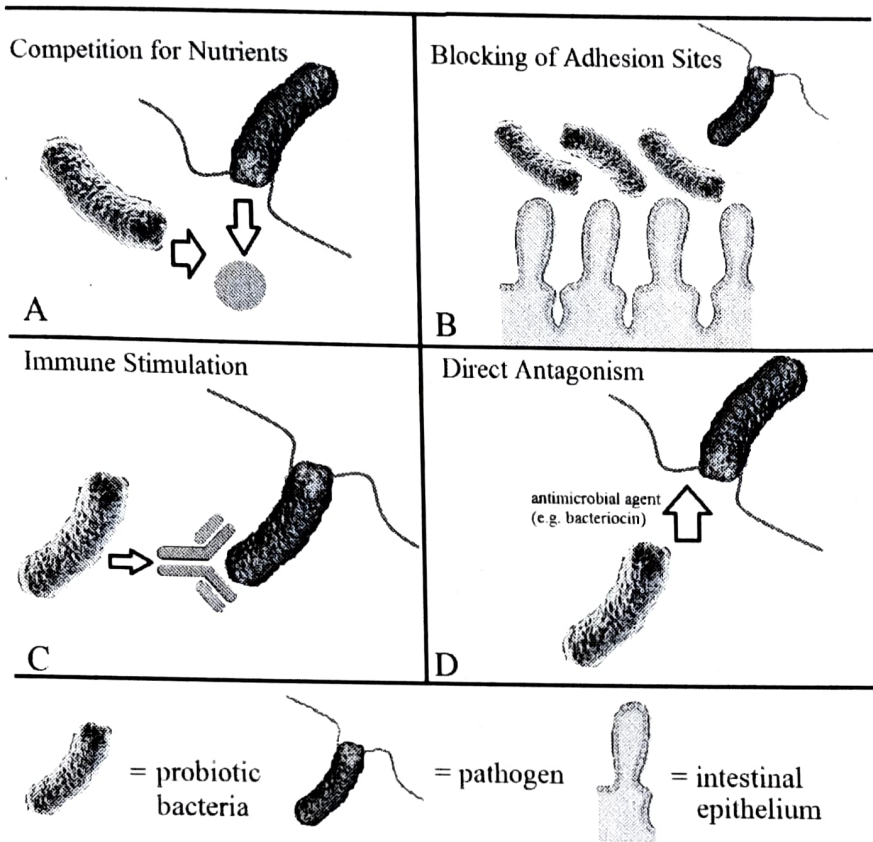
Foods are taken not just to fulfill the hunger and provide nutrition to the body, but it also prevents or reduces the development of nutrition related diseases thereby improving the physical and mental well-being of humans (Shori, 2015). Functional foods play an important role in not only providing the basic nutrients required for the growth, but also in providing health benefits to mankind (Cencic & Chingwaru, 2010). The term functional food was first used in Japan (Siro *et al.*, 2008).



(Courtesy: Creative Commons Images)

The first probiotic discovery was made in 1905 by Bulgarian physician and microbiologist Stamen Grigorov which was a strain of bacillus in **Bulgarian yoghurt**, known as *Lactobacillus bulgaricus*.

## How Probiotics Work

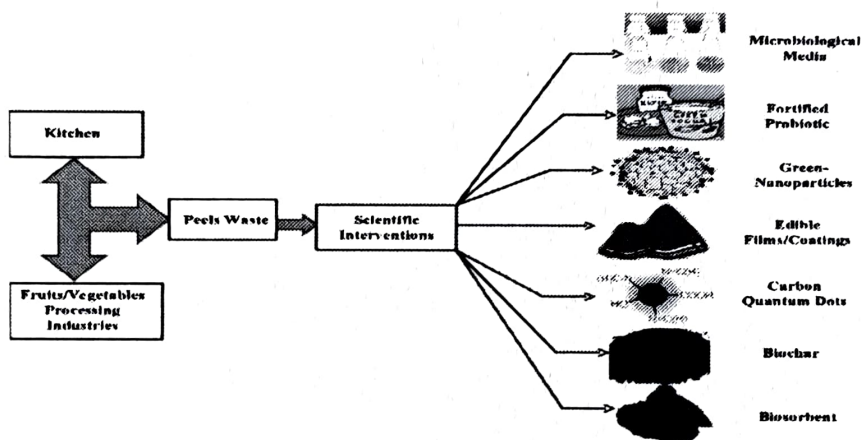


(Courtesy: Creative Commons Images)

Soil is a dynamic living natural body which is important for the functioning of terrestrial ecosystems. It is a balance between different factors viz., physical, chemical and biological. It is a non-renewable resource and its condition plays a major role in food production, environmental efficiency and global balance. The extensive use of chemical fertilizer create a negative impact in the soil thereby leading to pollution in the environment, which paved way for the agronomists and environmentalists to consider a biological approach for improving plant health and crop production.

According to Food and Agriculture organization (FAO) estimation (Plazzotta *et al.*, 2017 & NAAS, 2019) around 40% of the food produced in India is wasted. The estimated fruit and vegetable losses by the Ministry of Food Processing Industries (MFPI), India amounts to 12 and 21 million tons worth about 4.4 billion USD with a total food value loss and waste produced to be 10.6 billion USD (NAAS, 2019).

Fruit and vegetable waste (FVW) refers to the waste at different stages namely Collection, handling, Shipping and Processing that are thrown away (Chang *et al.*, 2006). This FVW could be produced at different steps from farm to consumer that involves both pre and post –consumer stages of food supply chain (Panda *et al.*, 2016). These FVW contain greater amount of phytochemical constituent and studies are being carried out to know their dietary fibres, phenolic compounds and extraction of various bioactive compounds (Galanakis, 2012). Various studies have proved that in peels and seeds of vegetables and fruits that are commonly used contain abundance of essential nutrients and phytochemical (Rudra *et al.*, 2015). As compared to the fruit pulp, the skin of avocados, grapes, lemons, seeds of jackfruits and mangoes contain 50% higher phenolic concentrations (Gorinstein *et al.*, 2001; Soong and Barlow, 2004)



### Use of Fruit and vegetable peels (Courtesy: Creative Commons Images)

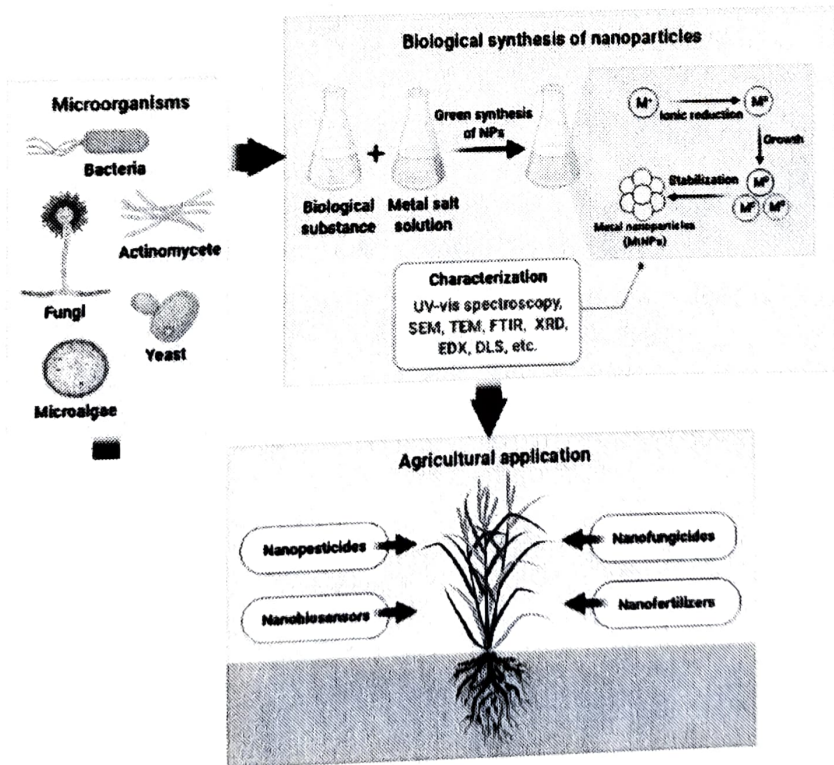
The current review summarizes the advances in the exploitation of waste fruits and vegetables peel as a valuable commodity of the future.

In the past two centuries, in the medical field, fruits have been used as a remedy for dry cough, severe thirst and sore throat. Recently, the demand for novel functional foods has increased and probiotics are commonly used worldwide as the main functional food products (Abdel-Hamid *et al.*, 2019). Studies in pomegranate, citrus, mango and barbery fig (*Opuntia ficus-indica*) peel have revealed the presence of antioxidants, fiber and Oligosaccharides (as prebiotics) (Cerezal and Duarte, 2005; Crizel *et al.*, 2013; Chan *et al.*, 2018; Coelho *et al.*, 2019). Some of the dietetic fibers obtained from fruits have been shown to have considerable effect on the viability of certain bacteria and these are recommended as an

ingredient in probiotic dairy foods (Santo *et al.*, 2012). Probiotics and dietary fiber have been proved to minimize the incidence of colon cancer and relieve constipation (Drago, 2019).

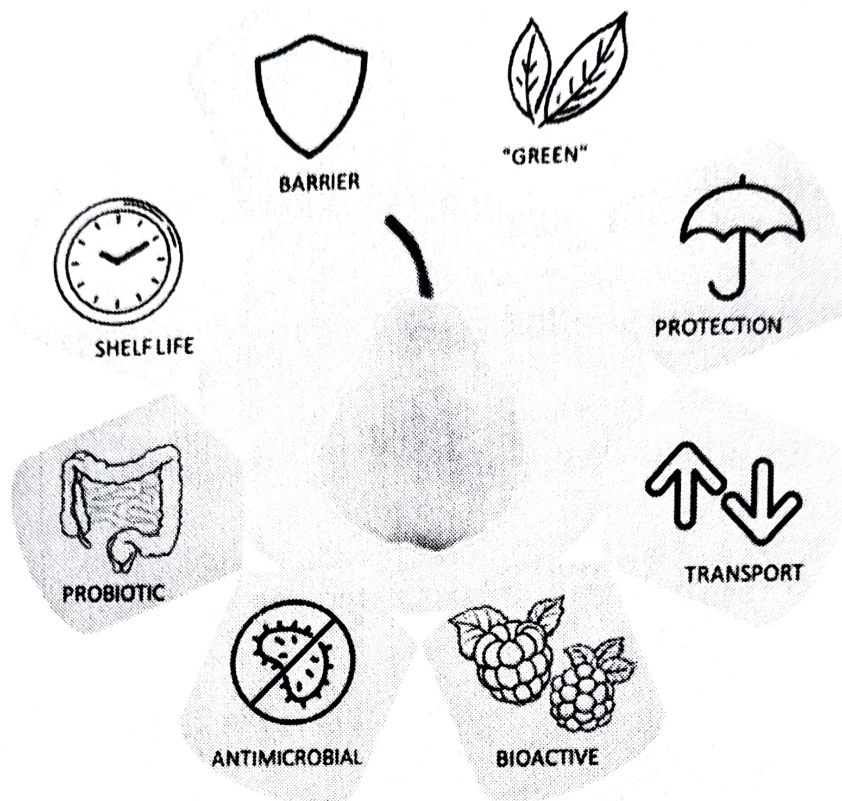
Yogurt is a probiotic dairy product and the probiotic yogurt prepared using pineapple peel powder improved the anticancer, antioxidant and antibacterial activities against *Escherichia coli*, but no effect was found against *Staphylococcus aureus* (Sah *et al.*, 2015). The addition of the peel powder of banana, apple and passion fruit in probiotic yogurt increased the growth of *Lactobacillus casei*, *Bifidobacterium animalis* subsp *lactis*, *Lactobacillus acidophilus* and *Lactobacillus paracasei* (Plazzotta *et al.*, 2017).

Nano-particles biosynthesised using FWV have emerged as a sustainable, eco-friendly and reliable technology with a minimum risk to human health and environment when compared with chemicals and toxic solvents involved in conventional method (Anastas and Warner, 2000).



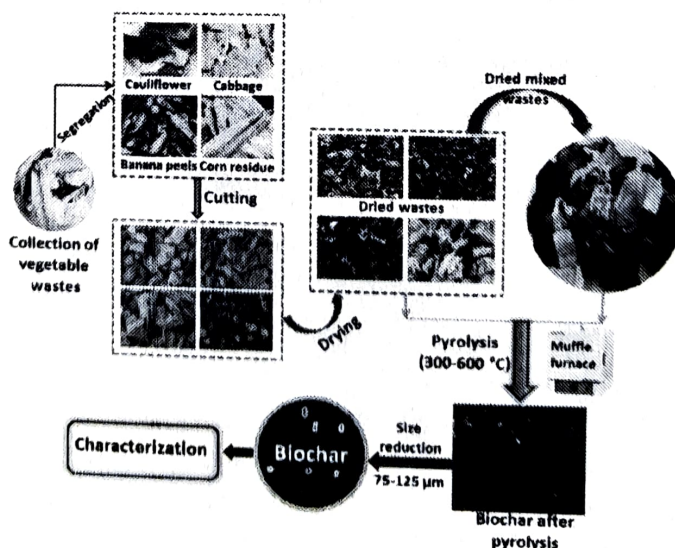
Green Synthesis of metallic nanoparticles using microorganisms (Courtesy: Creative Commons Images)





### Edible films and Coatings as food quality preservers (Courtesy: Creative Commons Images)

Biochar is a stable carbon-rich solid powder. This can be prepared by thermo chemical decomposition of organic feedstock material at high temperature under oxygen-free condition (Bruno *et al.*, 2009). For producing biochar and studying their yield and physiochemical properties, different types of food have been utilized (Oh *et al.*, 2017; Carmona-Cabello *et al.*, 2018).



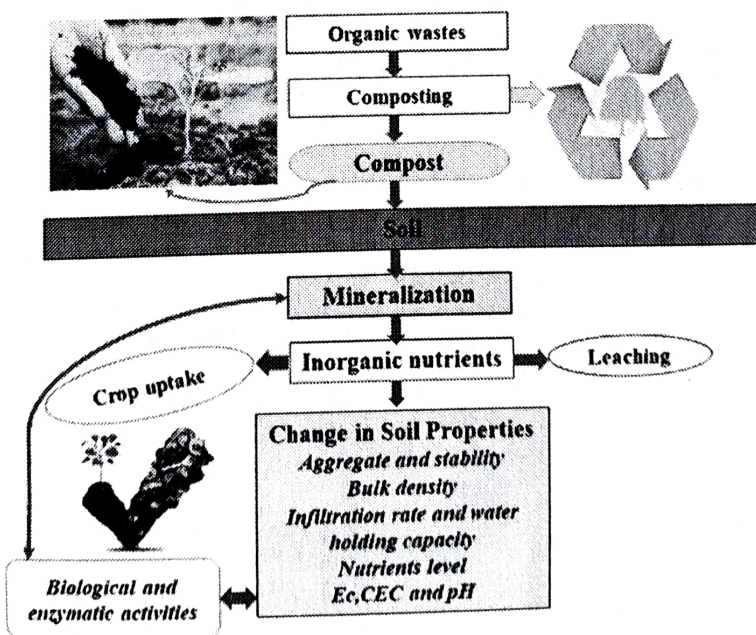
### Fruit and vegetable peel derived Biochar (Courtesy: Creative Commons Images)

## COMPOSTING

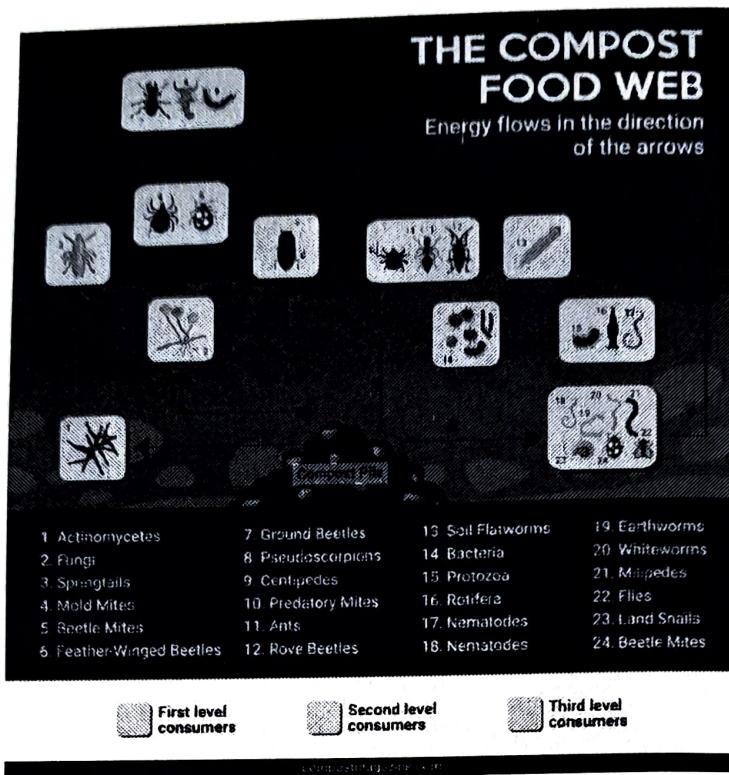
Probiotics is the method of introducing beneficial bacteria during composting process, thereby increasing the nutrient supply in the soil for plant growth.

Plant requires macro and micro nutrients for their growth at various stages and at varied concentrations. Nitrogen, phosphate and potassium are required for foliage growth, root development and flowering. Nowadays, the greater challenge for the organic farmers is to supply the plant with right quantities of these nutrients when they are needed. The use of composting technique helps the farmers to supply the plant naturally with the essential nutrition for the growth as well as for maintaining the soil structure. The plant growth this way has proved to be healthier and disease-resistant. According to Matsui (2009), composting is a way of recycling the organic waste into a valuable resource for agriculture.

For composting organic waste, three types of bacteria have been identified. The process involves the selection of one group of bacteria over another ACC to the type of organic waste that needs to be composted. The organic waste should be sorted carefully for proper selection of bacteria that can be work effectively and turn the waste into compost.



Schematic diagram of Compost mineralization after application to soil (Courtesy: Creative Commons Images)



## The Science of Composting (Courtesy: Creative Commons Images)

The addition of bacteria can be done in different ways;

1. In the case of rotten leaves where they carry *Bacillus sp.* bacteria can be introduced “naturally”.
2. In a powder/solution form, inoculation can be measured of applied scientifically as pure culture/mixed culture containing all three bacteria groups.

*Bacillus sp.* such as *B. subtilis.*, *B. Subtilus var. natto* and *B. thuringiensis* posses the ability to decompose any type of organic waste rapidly. These bacteria are aerobic and so strict aerobic conditions (requirement of  $O_2$ ) to be maintained throughout the process of composting.

Certain bacteria work in facultative anaerobic condition (eg. *Lactobacillus spp.*, *Lactococcus spp.*, *Enterococcus spp.*, *Pediococcus spp.* and *Leuconostoc spp.*) These bacteria prefer more anaerobic condition to decompose organic waste rich in carbohydrate content and sometimes work together with fermenting yeast species like *Saccharomyces spp.* and *Schizosaccharomyces spp.*

The main key for successful probiotics agriculture is the selection of correct species of bacteria as the catalytic function

for composting organic waste. Probiotic composting involves selection of catalytic bacterium or a mixture of them for fostering the presence of friendly bacteria in the compost which is the end product. Application of the probiotic compost into the soil helps in increasing the microbial count in the soil; thereby act as a microbial pesticide against bad microbes for the growing plants and crops.

Gram-positive bacteria belonging to the genus *Lactobacillus* and *Bifidobacterium* are the ones that are commonly used as probiotics. Apart from these *Lactococcus* spp., *Streptococcus thermophiles* and yeast *Saccharomyces boulardii* are also used in the probiotic industry (Gareari *et al.*, 2010).

Nowadays, the diverse symbiotic (*Rhizobium*, *Mesorhizobium*, *Bradyrhizobium*) associative (*Azospirillum*) and non-symbiotic (*Pseudomonas*, *Bacillus*, *Klebsiella*) rhizobacteria are being used as plant probiotics world wide to improve plant growth and development under different stress condition (Ahemad and Khan, 2011).

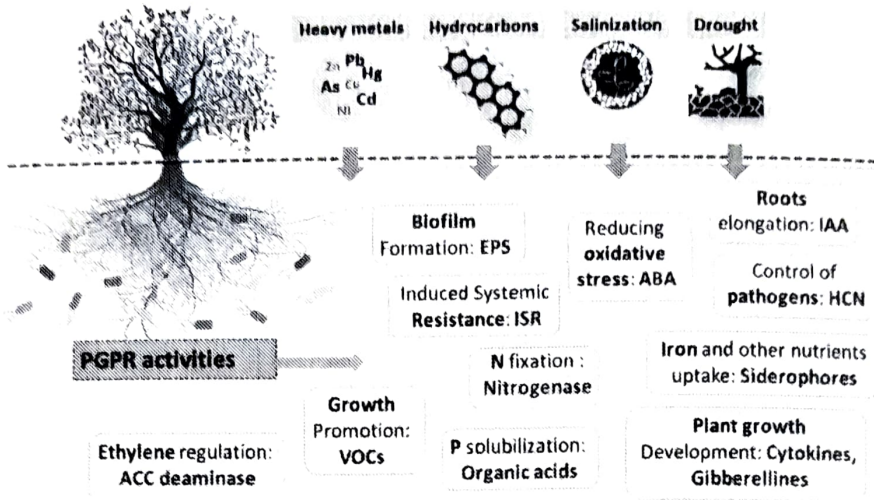
The inoculation of microorganisms as probiotics to plants not only supplements the required nutrients but also increase the growth and tolerance of the plant to various stresses.

## **PLANT GROWTH PROMOTING RHIZOBACTERIA**

The Rhizosphere contains a number of growth promoting beneficial microorganisms. Plant growth promoting Rhizobacteria (PGPR) are nothing but the bacteria that colonizes plant roots or any other parts of the plant and help the plant to enhance its growth and protect itself from diseases and other abiotic stresses.

The term PGPR was first coined by Kloeppner *et al.*, (1980). The three main characteristics of PGPR are

1. Should be able to colonize the root or any other part of the plant.
2. When used as probiotic, it should survive multiply and complete with the natural microflora for the expression of growth promoting activities.
3. Must promote plant growth.



### Role of PGPR (Courtesy: Creative Commons Images)

Now-a-days, agricultural production is mainly dependent on use of chemical fertilizer at a large scale. The excess use of these chemical fertilizers possesses harmful environmental effects (Adesmoye *et al.*, 2009). The use of efficient PGPR inoculants is a strategic to improve the growth of plant and reduce environmental problems (Hungria *et al.*, 2013).

### PGPR AS PROBIOTICS

Plant growth promoting rhizobacteria has the ability to provide various essential nutrients, thereby increasing the growth and productivity of the plants. Since they live in close association with plants, they could be used as probiotics for plants. This is the better way to grow plants by reducing the pollution due to chemical fertilizer and pesticides.

### TYPES OF PROBIOTIC PGPR

The PGPR apart from increasing the plant growth, also help in improving the soil texture as well as fertility. They may be classified based in their association with plants into

- Endophytic
- Symbiotic
- Associative
- Free-living

### Impact of Bacterial Probiotics on Plant Nutrient Content

Vitamins are very much essential for numerous physiological activities in life (Combs & Mcclung, 2016). Vitamin deficiency in humans could produce several diseases (Simkin *et al.*, 2016; Sechi

*et al.*, 2016). In order to decrease the world wide malnutrition, WHO has presented a proposal to improve the vitamin content in food (Garcia – Casal *et al.*, 2016). Certain vitamins have antioxidant effect (Dave & Shah, 1997). Plant antioxidants are one of the most active food compounds (Kris-Etherton *et al.*, 2002) and these are present in vegetables such as tomato, carrot, cabbage and fruits like cocoa, prunes, red grapes and citrus fruits (Grajek *et al.*, 2005). Based on the mode of action, these substances can be classified into 2 groups namely;

- Chemical substance that interrupt free radical chain propagation.
- Oxygen scavengers chelators that bind to ions involved in formation of the radicals (Grajek *et al.*, 2005).

Now-a-days, non-dairy probiotic foods are in consumer demands (Granato *et al.*, 2010) and these include food matrices from fruit, vegetables and cereals (Martins *et al.*, 2013).

In the modern system of agriculture, due to the increasing demand for food requirement, there is extensive use of chemical fertilizers that causes environment and human health problems (Garcia – Fraile *et al.*, 2015). Consumers are also aware not only about food safety and quality, but also about the food production system (Trienekens & Zurbier, 2008).

### Commercially available non-dairy based probiotic products (Courtesy: Creative Commons Images)

Probiotic Product	Type	Probiotic Microorganisms	Company
Avenly velle	Oat based drink	<i>Lactobacillus</i> and <i>Bifidobacterium</i>	Avenly Oy Ltd., Finland
Biola	Fruit Juice	<i>Lactobacillus rhamnosus</i> GG	Tine BA, Norway
Bioprofit	Fruit Juice	<i>Lactobacillus rhamnosus</i> GG, <i>Probiobacterium freudenreichii</i> , <i>Shermanii</i> JS	Valio Ltd., Finland
Bravo Friscus	Fruit Juice	<i>Lactobacillus plantarum</i> HEAL9, <i>Lactobacillus paracasei</i> 8700:2	Skanemajerier, Sweden
Cefilus	Fruit Juice	<i>Lactobacillus rhamnosus</i> GG	Valio Ltd., Finland
GoodBelly drink	Fruit Juice	<i>Lactobacillus plantarum</i> 299v	NextFoods, Colorado
Grainfields wholegrain liquid	Grains, beans and seeds	<i>Lactobacillus acidophilus</i> , <i>Lactobacillus delbreuckii</i> , <i>Saccharomyces boulardii</i> , <i>Saccharomyces cerevisiae</i>	AGM Foods Pvt. Ltd., Australia
Healthy life probiotics	Fruit Juice	<i>Lactobacillus paracasei</i> 8700:2, <i>Lactobacillus plantarum</i> Hea19	Golden circle, Australia

## CONCLUSION

In the present scenario, the development of sustainable solution for managing fruit and vegetable waste as become more important. Therefore a solution has to be developed to utilize these waste materials for attaining a social, environmental and economic benefit from these wastes.

Now-a-days plant probiotics are considered to be a safe means of agriculture due to their capacity to increase soil fertility, promote plant health and also safe for the environment. PGPR with its potential as probiotics could improve the yield because they control the pests and plant disease that are the main cause for one third of the plant losses.

This is the technology that is readily accessible to farmers in both developed and developing countries.

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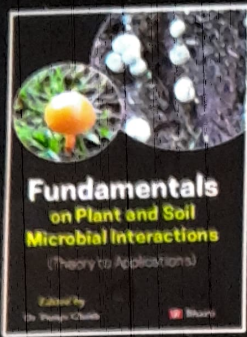
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## About the Book



Modified earth crust is soil which is organised and modified by the interactions of many microbial entities. The un-forceful interactions naturally governed by a large number of factors internally as well as externally. The overall power runs the process towards the micro-environment in which the organisms grow, flourish and reproduce for the next generations. So, soil is the medium as well as supportive system and the plants and microbes are the carrier that carry the nutrients as well as minerals and even transfer the complex form of matter to simple form for recycling the matter. The interaction of those organisms is the vital force to make the stable environment everywhere. Many chapters of this book represent the different components which make this book meaningful from theory to applications.

## About the Editor



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