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## Contents


1. **Lactic Acid Bacteria and Is Uses in Agriculure**
   *S.Saravanakumar ........................................................4*
2. **Concept of Rural Marketing in Modern India**
   *Ashish M Shendurse....................................................6*
3. **Nanotechnology in Food System**
   *C.Sharmila Rahale.......................................................9*
4. **Green Fluorescence Protein (GFP) for Detecion of Dndophyes in Plant Pathology**
   *P.Ahila Devi, Anuradha A and Ravi G .......................11*
5. **Potential of Rural Marketing in Indian Economy**
   *Ashish M.Shendurse..................................................13*
6. **Role of Phosphorus, Pahways of Phosphorus Loss from Agriculture and Strategies for Increasing P Use of Efficiency**
   *Anjali M.C...................................................................15*
7. **DNA Barcoding: A Rapid and Reliable Tool for Insect Species Identification**
   *Rishi K.Kalaria and H.V.Patel ....................................17*
8. **Role of Phytoliths (Silica) on Growth and Development of Crop**
   *Anjali M.C...................................................................21*
9. **Entomophily-Air Pollution and its Ineraction**
   *Kolli Bharghavi and Burjikindi Madhuri ......................23*
10. **Microbial Degradation of Insecicides**
    *Kolli Bharghavi and Burjikindi Madhuri .....................26*
11. **Huanglongbing (HLB) Disease of Citrus (Greening) and its Vector Asian Citrus Psyllid Diaphorina Citri Kuwayama (Homoptera: Psyllidae(- An Oulook**
    *Niranjanadevi J and Velprabakaran S .......................29*

## 1. AGRICULTURAL MICROBIOLOGY

# Lactic Acid Bacteria and Its Uses in Agriculture

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Lactic acid bacteria (LAB) play an important role in food, agricultural, and clinical applications. The general description of the bacteria included in the group is gram-positive, non-sporing, non-respiring cocci or rods, which produce lactic acid as the major end product during the fermentation of carbohydrates. Lactic acid bacteria are ubiquitous microorganisms that can be beneficial in crop and livestock production. With their long history of use in food preservation by many world cultures (Nordqvist 2004), LAB are generally recognized as safe for human consumption. By producing lactic acid as a fermentation metabolite, these microorganisms prolong storage, preserve nutritive value, and enhance flavors of otherwise perishable foods. LAB are easy to collect and economical to culture, store, and use.

The primary producers of lactic acid in natural environments are lactic acid bacteria. These include beneficial microbes from genera such as Lactobacillus, Streptococcus, and Pediococcus. These bacteria are found in various environments, including soil, plant surfaces, and decomposing organic matter, where they convert sugars into lactic acid through fermentation. Lactic acid is also produced in plant tissues under anaerobic conditions, such as waterlogged soils. In these environments, it can be a temporary product of anaerobic respiration in plants.

### Mechanisms of Lactic Acid Production

Fermentation: The primary pathway for lactic acid production is through fermentation, where glucose is converted into lactic acid in the absence of oxygen. This process is facilitated by LAB and is crucial in environments with limited oxygen availability.

Enzymatic Activity: The conversion of pyruvic acid to lactic acid is catalysed by the enzyme lactate dehydrogenase. This enzymatic activity is essential in the metabolic pathways of LAB and occurs under anaerobic conditions.

### Production of LAB Culture

- Wash rice grains and collect the first two rinses of cloudy water.
- Fill a clean glass jar about 2 /3 full with rice rinse water. Label the jar with date and contents.
- Cover the mouth of the jar with breathable cloth (such as muslin) or paper and secure with rubber bands or ties to keep out pests. Store at room temperature away from direct light. Be careful not to shake or move the jar while it ferments.
- After 3 to 5 days, LAB will multiply and give off a slightly sour odour. There will be a mat of semi-solid material floating on the top of the cloudy liquid in the jar. Collect only the cloudy liquid (fermented rinse water) by pouring off and discarding the mat layer.
- Depending on the size of your glass jar, measure one part of fermented rinse-water and add 10 parts of milk to fill your jar 2 /3 full.
- Cover the mouth of the jar with cloth or paper and secure with rubber bands or ties to keep out pests. Store at room temperature away from direct light. Be careful not to shake or move the jar while it ferments.
- After 3 to 5 days, the contents of the jar will separate into a floating solid fraction and a yellow liquid fraction. It may take longer in cooler climates. The yellow liquid is the LAB culture, which must be kept alive.
- Pour off the liquid fraction, being careful not to mix any solids back into the LAB

culture. Store LAB culture in a loosely capped plastic or glass bottle labelled with the date and contents.

- LAB culture not used within a week should be refrigerated, or if it must be kept at room temperature, add an equal amount (by weight) of brown sugar. Keep the bottle loosely capped to release gases formed by fermentation, or the container may burst.
- LAB culture may be kept refrigerated for 6 months. Continue to keep the bottle loosely capped to release gases.
- LAB culture should have a sweet odour; if the odour becomes unpleasant (rotten) after it has been stored, discard it and make a new batch. LAB culture may be kept refrigerated for 6 months. Continue to keep the bottle loosely capped to release gases.

## LAB Culture Usage in Plant Production

LAB culture is diluted at a 1:1,000 ratio with water mixed with a plant nutrient solution such as fermented plant juice and applied as a foliar spray to leaf surfaces of leaf or fruit crops. Over-application of LAB culture to fruit crops may result in the loss of sweetness (lowered brix) of fruits. Apply sparingly in the latter stages of the fruiting season. LAB culture can also be used in conjunction with other nutrient solutions to treat seeds before planting. This improves seed germination, inoculates the seed with beneficial microbes, and deters fungal problems, such as “damping off” (Hamed et al. 2011). LAB is used with IMO (indigenous microorganisms) in Natural Farming in making composts or compost teas for soil preparation prior to planting (Park and DuPonte 2008). Application of LAB culture can accelerate the decomposition of organic amendments in soils and enhance the release of plant nutrients for absorption.

**Soil Microbial Ecology:** Lactic acid influences the microbial ecology of the soil. Its production can lead to soil acidification, which can impact nutrient availability and microbial community dynamics.

**Plant Growth and Nutrition**: In the rhizosphere, lactic acid-producing bacteria can enhance nutrient solubilization, making essential nutrients more available to plants. This can lead to improved plant growth, particularly in nutrient-deficient soils.

**Natural Bio control Agent:** Some LAB strains, through lactic acid production, can suppress plant pathogens, thereby reducing the incidence of diseases and diminishing the need for chemical fungicides.

## LAB Culture Used in Livestock Production

LAB culture can transform a malodorous, anaerobic livestock pen, for example, into an odourless system when used in conjunction with an IMO-inoculated deep litter system (DuPonte and Fischer 2012). LAB culture can also be given to most livestock species to consume through their feed and/or water as a probiotic to help foster a healthy gut flora, enhance their immune systems, and aid in digestion

## Benefits to Agricultural and Environmental Systems

Sustainable Agriculture Practices: Utilizing LAB as biofertilizers or biocontrol agents offers an eco-friendly alternative to chemical inputs in agriculture. This approach supports sustainable farming practices and soil health.

**Enhancing Soil Fertility:** Lactic acid production contributes to the breakdown of organic matter in soil, releasing nutrients and improving soil fertility.

**Stress Tolerance in Plants:** LAB can induce systemic resistance in plants, enhancing their resilience against environmental stresses and diseases.

LAB are the most commonly used microorganisms for the fermentation and preservation of foods. Their importance is associated mainly with their safe metabolic activity while growing in foods utilising available sugar for the production of organic acids and other metabolites.

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## 2. AGRIBUSINESS MANAGEMENT

# Concept of Rural Marketing in Modern India

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## Introduction

The concept of 'Rural Marketing' in Indian economy has always played an influential role in the lives of people. In India, leaving out a few metropolitan cities, all the districts and industrial townships are connected with rural markets (Jain and Saini, 2012). Typically, a rural market will represent a community in a rural area with a population of 2500 to 30000 (Ashu, 2015).

The Indian rural market generates about 50 per cent of the country's gross domestic product (GDP) (Nisha, 2016). Therefore, a distinct marketing strategy i.e. rural marketing has arisen. Rural marketing comprises distributing manufactured or managed inputs or facilities to rural customers or producers. The rural market in Indian economy creates approximately half of the nation's income (Kaur, 2015) and can be classified into 2 main categories i.e. the market for buyer goods that includes both non-durable and durable goods and the market for farm inputs that contains fertilizers, seeds, pesticides, etc (Ashu, 2015).

The Indian rural market is not a distinct unit in itself and it is extremely influenced by the behavioural and sociological factors functioning in the country. The rural market in India, with its enormous scale and demand base creats countless prospects for marketers (Kaur, 2015; Sirisha, 2016). 'Go Rural' is the slogan given by the marketing guru's after analyzing the socio-economic changes in Indian villages (Anand and Tyagi, 2017). With the urban markets getting saturated for several categories of consumer goods and with rising rural incomes, marketing executives are waving out and realizing the strengths of the large rural markets as they attempt to expand their markets. Marketers and manufactures are increasingly aware of the burgeoning purchasing power, vast size and demand of the consumers. Efforts are now on to understand the attitude of rural consumers (Meenakshi and Takkar, 2015). Marketers have understood that rural India has now converted into the burning spot for corporate firms with incredible potential and with cumulative emphasis of the policy makers on adding money to drive the rural economy. There are various multinational organizations that have tried to rap the potential of rural market through good marketing strategies (Kaur, 2015). Among those Multi-National Companies like Hindustan Liver, Coca-Cola, LG electronics, Britannia, Colgate Palmolive and foreign invested telecom/insurance companies have made headway. Rural market account for half the total market for TV sets, Fans, Pressure cookers and bicycles, washing soap and tooth powder (Jain and Saini, 2012).

Currently, rural marketing is a striking term related to its mid and late 80s. The rural markets have been growing steadily since 1980s and is now bigger than the urban markets for both FMCG (35%share of total market) and durables (59%) (Kumar and Naruka, 2015). Nowadays, enhancement in living style and expansion of rural area is crucial for the growth of Indian economy (Kumud and Agrawal, 2013). Rural marketing is a emerging concept, and as a share of any economy has unexploited potential. In recent years, rural markets have developed importance, as the overall growth of the economy has caused into substantial rise in the purchasing power of the rural people and likings of rural people are also getting transformed. So, every marketing player is keen to invest in rural markets (Sirisha, 2016).

## Concept of Rural Marketing

Rural Marketing is defined as a purpose that accomplishes all activities involved in evaluating, inspiring and changing the purchasing power of rural consumers into an active demand for specific services and products and moving these services and products to the rural people to produce satisfaction and a better living standard and thus achieving organizational goals. The process should be able to span the attitudinal and socio-economic discrepancy between the rural and urban consumers (Rafiuddin and Ahmed, 2011).

- **Urban to Rural (U 2 R):** A key part of rural marketing comes into this category. It contains the transactions of urban marketers who sell their goods and services in rural areas, like fertilizers, pesticides, seeds, bicycles, tractors, consumer durables, FMCG products, etc.
- **Rural to Urban (R 2 U):** Transactions in this category essentially contains agricultural marketing where a rural producer seeks to sell his produce in an urban market like spices, fruits and vegetables, seeds, forest produce, milk and related products, etc.
- **Rural to Rural (R 2 R):** This comprises the activities that take place between two villages in nearby proximity to each other, like dress materials, handicrafts and bullock carts, agricultural tools, etc.

## Types of Rural Markets in India

- **Haats** - Mostly for weekly market for all commodities.
- **Mandies** - Mostly for all types of grains.
- **Regulated Markets** - These markets are for the farmers to take their produce for sale. These markets facilitate farmers for instant cash payments.
- **Co-Operative Marketing** - It is for the rural producers' common interest that is to rise the incomes of the farmers and avoid misuse from the middlemen (Jain and Saini, 2012).

## Significance of Rural Marketing

Presently, rural markets have developed significance in nations like India and China, as the complete growth of the economy has lead to substantial growth in the purchasing power of the rural people. The rural market in India has a massive demand base and offers countless opportunities to marketers. Two-thirds of Indian customers live in rural areas and creates almost half of the country's income. The reasons for heading into the rural areas is because the rural market is zooming ahead at around 25 per cent annually. The rural market is growing faster than urban India now (Ashu, 2015).

The overload of the urban market has fetched importance to rural market. So, the marketers are seeing for spreading their product categories to an untapped market i.e. the rural market. E.g. Hindustan Unilever Limited (HUL) initiated a project 'Shakti' in rural India, which is not only helping their company attain revenue but also helping the poor women of the village to get some money which is certainly going to rise their purchasing power. Also, this will boost their brand loyalty as well as appreciation in rural area. Similarly, the ITC E-Chaupal is helping the poor farmers to get all the information about the weather as well as the market price of the food grains they are producing. In other view, these activities are also helping the companies increase their brand value too. So, like that the significance of the rural market has increased due to the saturation of the urban market as well as plenty of opportunities available there and also companies which will lead the way will be benefited as shown by the success of HUL and ITC initiatives (Jain and Saini, 2012).

## Conclusion

Rural marketing plays a vital role in the development of country's economy. Indian rural market is undoubtedly complex but there are some simple truths that we need to accept. The rural consumers are very value-conscious. They may or may not have purchasing power, but they can make a difference to the company's growth if concentrated. A small increase in rural income, results in an exponential increase in buying power. The growing power of the rural consumer is an opportunity for the companies to flock to the rural markets. The market share of urban market when compared to the rural market is low; hence if business organizations concentrate on rural markets their sales and market share will get increased.

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# 3. NANOTECHNOLOGY

## Nanotechnology in Food System

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In order to increase food safety, quality, and shelf life, nanotechnology is employed in the food sector. It can be applied in many areas of food production and processing including Food Packaging, Food Processing, Food Quality and Food safety.

### Food Packaging

Strongness, biodegradability, and the ability to let in gas and moisture are all necessary qualities in a packing material. Compared to traditional packaging techniques, "smart" and "active" food packaging made of nanotechnology offers a number of benefits. These include enhanced mechanical strength, barrier qualities, and antimicrobial films in addition to nanosensing for pathogen detection and consumer food safety alerts. Enhancing food packaging can also be accomplished by using nanocomposites as an active material for coating and packing. The use of organic substances such as bacteriocins, organic acids, and essential oils in polymeric matrices as antimicrobial packaging piqued the interest of numerous researchers. Since these chemicals are extremely sensitive to these physical conditions, they cannot be used in the several food processing procedures that call for high temperatures and pressures. Strong antibacterial activity at low concentrations and greater stability in harsh environments can be attained with inorganic nanoparticles. Consequently, there has been a lot of interest in applying these nanoparticles to antimicrobial food packaging in recent years. According to Soares et al. (2009), antimicrobial packaging is essentially a type of active packaging that comes into touch with the food product or the headspace inside in order to prevent or delay any potential microbial growth on food surfaces. There have been numerous reports of the antibacterial properties of nanoparticles, including silver, copper, chitosan, and metal oxide nanoparticles like zinc oxide or titanium oxide.

Nanocomposite and nanolaminates have been actively employed in food packaging to provide a barrier from high heat and mechanical damage, extending food shelf-life. Nanoparticle utilization is not restricted to antimicrobial food packaging. In this sense, food of higher quality and longer shelf life is provided by the inclusion of nanoparticles into packaging materials. The goal of developing polymer composites is to provide packing materials that are more thermostable and mechanically strong.. Improved polymer composites are being made by using a lot of inorganic or organic fillers. The development of more affordable, resilient packaging materials has been made possible by the integration of nanoparticles into polymers.

### Food Processing

The main applications of nanotechnology in food processing are texture improvement, encapsulation of food additives or components, creation of new flavors and sensations, control over the release of flavors, and increased nutrient content bioavailability. The various functional ingredients used in the food industry are antioxidants, antimicrobials, vitamins, flavoring agents, coloring agents, and preservatives. These materials are available in a variety of physical and molecular forms (physical states and molecular weights & polarities).

When it comes to encapsulation and release efficiency, nanoparticles outperform conventional encapsulation technologies. In addition to masking tastes or odors, nanoencapsulations also show compatibility with other compounds in the system, regulate how active ingredients interact with the food matrix, control the release of the active agents, guarantee availability at a predetermined time and rate, and shield them from biological, chemical, or moisture-induced degradation during processing, storage, and use. Furthermore, because these delivery systems are smaller, they may more easily pierce tissues and effectively transport active substances to the desired locations throughout the body. Different encapsulating delivery systems, based on synthetic and natural polymers, have been developed to enhance the bioavailability and preserve the active ingredients in food.

## Food Quality

A variety of methods for raising food quality and taste are made possible by nanotechnology. In order to enhance taste release and retention and provide culinary balance, nanoencapsulation techniques have been widely employed. These techniques are used for the extremely reactive and unstable plant pigment anthocyanins, which have a variety of biological activities. Because of their subcellular size, which increases therapeutic bioavailability, nanoparticles offer a viable method of increasing the bioavailability of nutraceutical components in comparison to bigger particles, which typically release encapsulated compounds more slowly and over longer time periods. Numerous metallic oxides, including silicon dioxide ($SiO_2$) and titanium dioxide, have long been employed in food products as colorants or flow agents. One of the most popular food nanomaterials for encapsulating tastes or scents in food products is $SiO_2$.

Most bioactive substances, including vitamins, proteins, lipids, and carbohydrates, are sensitive to the stomach and duodenum's high acidity and strong enzyme activity. Due to their poor water solubility, these bioactive chemicals are difficult to absorb in non-capsulated form. However, encapsulation not only makes them resistant to such harsh conditions, but also makes it easier for them to do so in food products. Tiny edible capsules based on nanoparticles are being developed to enhance the distribution of vitamins, medications, or delicate micronutrients in everyday meals and offer major health advantages.

## Food Safety

By slowing down the degradation processes or preventing degradation until the product is delivered at the target site, nanoencapsulation of these bioactive components, which are frequently degraded in functional foods and ultimately lead to inactivation due to the hostile environment, extends the shelf-life of food products. Additionally, edible nanocoatings on a variety of food components may operate as a barrier against moisture and gas exchange, as well as transmit antioxidants, enzymes, tastes, colors, and anti-browning agents. They may also extend the shelf life of manufactured meals beyond the point at which the packaging is opened. It is frequently possible to slow down chemical degradation processes by encapsulating functional components within the droplets and manipulating the properties of the interfacial layer that surrounds them.

In addition to the many benefits that nanotechnology offers the food sector, it is important to consider the safety risks related to nanomaterials. In order to ensure product quality, health and safety, and environmental restrictions, regulatory bodies must also create some criteria for commercial products.

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# 4. PLANT PATHOLOGY

# Green Fluorescence Protein (GFP) for Detection of Endophytes in Plant Pathology

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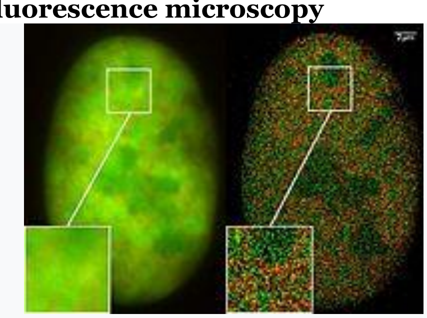
## Introduction

The green fluorescent protein (GFP) is a protein that exhibits bright green fluorescence when exposed to light in the blue to ultraviolet range. The label GFP traditionally refers to the protein first isolated from the jellyfish Aequorea victoria and is sometimes called avGFP. However, GFPs have been found in other organisms including corals, sea anemones, zoanithids, copepods and lancelets.

The GFP from A. victoria has a major excitation peak at a wavelength of 395 nm and a minor one at 475 nm. Its emission peak is at 509 nm, which is in the lower green portion of the visible spectrum. The fluorescence quantum yield (QY) of GFP is 0.79. The GFP from the sea pansy (Renilla reniformis) has a single major excitation peak at 498 nm. GFP makes for an excellent tool in many forms of biology due to its ability to form an internal chromophore without requiring any accessory cofactors, gene products, or enzymes / substrates other than molecular oxygen.

Due to the potential for widespread usage and the evolving needs of researchers, many different mutants of GFP have been engineered. The first major improvement was a single point mutation (S65T) reported in 1995 in Nature by Roger Tsien. This mutation dramatically improved the spectral characteristics of GFP, resulting in increased fluorescence, photostability, and a shift of the major excitation peak to 488 nm, with the peak emission kept at 509 nm. This matched the spectral characteristics of commonly available FITC filter sets, increasing the practicality of use by the general researcher. A 37 C folding efficiency (F64L) point mutant to this scaffold, yielding enhanced GFP (EGFP), was discovered in 1995 by the laboratories of Thastrup and Falkow. EGFP allowed the practical use of GFPs in mammalian cells. EGFP has an extinction coefficient (denoted ε) of 55,000 $M^{-1}cm^{-1}$. The fluorescence quantum yield (QY) of EGFP is 0.60. The relative brightness, expressed as ε•QY, is 33,000 $M^{-1}cm^{-1}$.

## Fluorescence microscopy



Different proteins produce different fluorescent colors when exposed to ultraviolet light.

There are many GFP-like proteins that, despite being in the same protein family as GFP, are not directly derived from Aequorea victoria. These include dsRed, eqFP611, Dronpa, TagRFPs, KFP, EosFP/IrisFP, Dendra, and so on. Having been developed from proteins in different organisms, these proteins can sometimes display unanticipated approaches to chromophore formation. Some of these, such as KFP, are developed from naturally non- or weakly-fluorescent proteins to be greatly improved upon by mutagenesis.When GFP-like barrels of different spectra characteristics are used, the excitation spectra of one chromophore can be used to power another chromophore (FRET), allowing for conversion between wavelengths of light.

## Structure

GFP has a beta barrel structure consisting of eleven β-strands with a pleated sheet arrangement, with an alpha helix containing the covalently bonded chromophore 4-(p-hydroxybenzylidene) imidazolidin-5-one (HBI) running through the center. Five shorter alpha helices form caps on the ends of the structure. The beta barrel structure is a nearly perfect cylinder, 42Å long and 24Å in diameter (some studies have reported a diameter of 30Å creating what is referred to as a "β-can" formation, which is unique to the GFP-like family. HBI, the spontaneously modified form of the tripeptide Ser65–Tyr66–Gly67, is nonfluorescent in the absence of the properly folded GFP scaffold and exists mainly in the un-ionized phenol form in wtGFP.] Inward-facing sidechains of the barrel induce specific cyclization reactions in Ser65–Tyr66–Gly67 that induce ionization of HBI to the phenolate form and chromophore formation.

## Fusion Proteins

The availability of GFP and its derivatives has thoroughly redefined fluorescence microscopy and the way it is used in cell biology and other biological disciplines.] While most small fluorescent molecules such as FITC (fluorescein isothiocyanate) are strongly phototoxic when used in live cells, fluorescent proteins such as GFP are usually much less harmful when illuminated in living cells. This has triggered the development of highly automated live-cell fluorescence microscopy systems, which can be used to observe cells over time expressing one or more proteins tagged with fluorescent proteins.

There are many techniques to utilize GFP in a live cell imaging experiment. The most direct way of utilizing GFP is to directly attach it to a protein of interest. For example, GFP can be included in a plasmid expressing other genes to indicate a successful transfection of a gene of interest. Another method is to use a GFP that contains a mutation where the fluorescence will change from green to yellow over time, which is referred to as a fluorescent timer. With the fluorescent timer, researchers can study the state of protein production such as recently activated, continuously activated, or recently deactivated based on the color reported by the fluorescent protein. In yet another example, scientist have modified GFP to become active only after exposure to irradiation giving researchers a tool to selectively activate certain portions of a cell and observe where proteins tagged with the GFP move from the starting location. These are only two examples in a burgeoning field of fluorescent microcopy and a more complete review of biosensors utilizing GFP and other fluorescent proteins can be found here.

For example, GFP had been widely used in labelling the spermatozoa of various organisms for identification purposes as in Drosophila melanogaster, where expression of GFP can be used as a marker for a particular characteristic. GFP can also be expressed in different structures enabling morphological distinction. In such cases, the gene for the production of GFP is incorporated into the genome of the organism in the region of the DNA that codes for the target proteins and that is controlled by the same regulatory sequence; that is, the gene's regulatory sequence now controls the production of GFP, in addition to the tagged protein(s). In cells where the gene is expressed, and the tagged proteins are produced, GFP is produced at the same time. Thus, only those cells in which the tagged gene is expressed, or the target proteins are produced, will fluoresce when observed under fluorescence microscopy. Analysis of such time lapse movies has redefined the understanding of many biological processes including protein folding, protein transport, and RNA dynamics, which in the past had been studied using fixed (i.e., dead) material. Obtained data are also used to calibrate mathematical models of intracellular systems and to estimate rates of gene expression. Similarly, GFP can be used as an indicator of protein expression in heterologous systems. In this scenario, fusion proteins containing GFP are introduced indirectly, using RNA of the construct, or directly, with the tagged protein itself. This method is useful for studying structural and functional characteristics of the tagged protein on a macromolecular or single-molecule scale with fluorescence microscopy.

**Advantages**

GFP makes for an excellent tool in many forms of biology due to its ability to form an internal chromophore without requiring any accessory cofactors, gene products, or enzymes / substrates other than molecular oxygen. In cell and molecular biology, the GFP gene is frequently used as a reporter of expression.

## 5. AGRIBUSINESS MANAGEMENT

# Potential of Rural Marketing in Indian Economy

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### Introduction

The immense potential of rural market realizes the huge untapped needs of the rural mass, the growing rural economy and the increasing media penetration and brand awareness which make this market extremely attractive to marketers (Goswami, 2009). The growth statistics for FMCG and Consumer Durables sector suggests huge potential for Indian Rural markets (Paninchukunnath, 2010). Moreover, developments in infrastructure, transport and communication facilities have increased the scope of the rural market. Indian rural marketing has always been complex to forecast and consist of special uniqueness. As two-thirds of the Indian population live in rural areas, the market is vast than expected and many companies are doing very good business in the rural market (Jain and Saini, 2012).

For many years, rural India was not much acknowledged by the retailers. But as the 'bottom of the pyramid' is getting empowered with education, higher purchasing power and awareness, companies are looking for opportunities available in hinterlands. The basic scope of this novel initiative will be the mutual benefits of the rural entrepreneurs and industries. Moreover, the key role of information technology, provided and maintained by the company for building linkages, and used by local farmers brings about transparency, increased access to information and rural transformation. The prime scope of this model is the creation of opportunities for the rural entrepreneurs for product differentiation and innovation by offering them choices. The involvement of the private sector at the rural product and market development can also provide opportunities for the development of new services and values to the customers, which will find application in the developed markets. It will be worth mentioning that building a sustainable market linkage through industry's intervention will also empower the rural mass (producers, farmers & entrepreneurs) to cope with socio-economic problems in the rural society and will ensure economic self-reliance (Kaur, 2015; Meenakshi and Takkar, 2015; Nisha, 2016).

### Potential in Rural Marketing

Following points elucidate the potential in rural marketing (Rafiuddin and Ahmed, 2011; Arora, 2015; Meenakshi and Takkar, 2015):

- **Increase in Population and Increase in Demand**: The rural market in India is vast and scattered. It covers maximum population which means maximum numbers of consumers. More than 80% of rural markets in India still do not have access to any sort of organized marketing. CRISIL studies estimates that over 60% India's population would be residing in rural areas in 2026 which creates opportunities for markets to serve rural/semi urban consumers.
- **Growth in Market**: The market has been growing at 3-4% per annum adding more than one million new consumers every year. Consumer is brand loyal and understands symbols better. The 12.2% of the world's consumers live in India. Rural

households form 72% of the total households. This puts the rural market at roughly 720 million customers. The total income in rural India (about 43% of total national income) is expected to increase in coming years.

- **Accessibility of Markets**: The attraction of a market depends not only on its potential but also on its accessibility. The road network has facilitated a systemized product distribution system to villages. An increasing number of companies are supplying to village markets directly. Increasing direct contacts to villages helps product promotion and availability of the product in the village shop.
- **Increase in Literacy Rate**: Literacy rate is increasing in rural areas. This brings social-cultural changes in rural consumer's behaviour in purchasing products towards brands. Increase in literacy helps in booming their purchasing power and now they prefer to buy branded products.
- **Consumer Behaviour Changes**: Increased literacy and greater awareness in rural markets create new demands and discriminating buyers. This is observed more in the younger generation. In villages today, this segment of buyers consumes a large variety of products, both durables and non-durables. There is a visible increase in consumption and use of a variety of products.
- **Competition in Urban Markets**: Intensified competition in urban markets increases costs and reduces market share. The rural markets are therefore increasingly attractive in relation to urban markets.
- **Increase in Disposable Income/Purchasing Power**: Income level of rural people has improved due to modern farming policies, industrialization of rural areas and growth of service sector. Different projects started by private agencies and government helped rural population to meet their basic needs. Government provides loan to rural sector at low interest rate by microfinance initiatives and Kisan credit cards had also boost the income level of rural people which provide potential opportunities to different companies to enter in rural areas.
- **Green Card / Credit Card for Farmers**: The government-initiated credit cards for farmers through public sector banks. Canara bank and Andhra bank were the pioneers in the launch of the Kisan Credit Card. The farmer had a choice to take short- or medium-term loans through these credit cards to buy seeds, fertilizers, etc. This enabled them to produce more and thereby increase their income.
- **IT in Rural India**: Internet technology plays an important role in rural India and brings socio-culture changes in rural markets. Today's rural children and youth are growing up in environment where they have information access to education opportunities, health, legal advice, land records, mandi prices, weather forecasts, bank loans, livelihood options, worldwide news, etc. which changes the language of brand communication in rural India. Web connectivity creates a great demand of goods and services in rural markets which helped in growth of rural marketing. As the IT culture moves into rural India, the possibilities of change are becoming visible.
- **Impact of Globalization**: The impact of globalization is felt in rural India as much as in urban sector. However, it is slow but it has its impact on target groups like farmers, youth and women. Farmers, today 'keep in touch' with the latest information and maximize both ends. Animal feed producers no longer look at state level agencies. They keep their cell phones constantly connected to global markets. Surely, price movements and product's availability in the international market place seem to drive their local business strategies.

On youth, its impact is on knowledge and information and while on women it still depends on the socio-economic aspect. The marketers who understand the rural consumer are fine tuning their strategies and are sure to reap benefits in the coming years.

- **Improved Infrastructure**: Rapid development of rural infrastructure is also major attraction for marketers. Infrastructure includes rail, water supply, electricity, good transport facilities and good financial facilities through banks.
- **Mass Media/ Broadcasting Media**: It is playing a major role in rural markets of India. As people are less educated, market is heterogeneous and huge, special attention and strategies are required for rural markets of India, and broadcasting media is overcoming all these flaws and proving to be the much loved by both buyer and seller (Anand and Tyagi, 2017). Moreover, the mass Media has created increased demand for goods and services in rural areas. Smart marketers are employing the right mix of conventional and non-conventional media to create increased demand for products. The role of cable television has been noteworthy in bringing about the change in rural people's mindset and influencing their lifestyles (Rafiuddin and Ahmed, 2011).
- **Favourable Government Policies and Development Programmes**: The central and state Government has made many initiative development programmes for development of rural areas through five-year plans which show great investment in rural market. The current and previous five-year plans give high priority to development of rural areas, transportation, communication and other services etc which generate income for rural people and increase their standard of living.

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## 6. SOILSCIENCE

# Role of Phosphorus, Pathways of Phosphorus Loss from Agriculture and Strategies for Increasing P Use Efficiency

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### Phosphorus Reserves

Phosphate rock is a naturly occurring mineral containing a high concentration of phosphate. About 95% of the phosphate rock mined is used to produce fertilizers, animal feeds and pesticides. **Sedimentary deposits** have provided about 80-90% of world production and mostly distributed in morocco and other African countries. **Igneous deposits** have provided about 10-20 % of word production and exploited in the Russian federation, Canada, South Africa, Brazil, Finland and Zimbabwe. These deposits usually contain varieties of fluorapatite that are relatively unreactive and least suitable for direct application.

Rock phosphate reserve across the globe is estimated at 18,000,000 thousand metric tonnes (Us Geological survey 2008). Nearly, 85% of reserve is distributed in USA, morocco and Africa. Based on the current extraction rates and economic conditions more than half of these countries will have exceeded the life of their reserves in less than 20 years.

India has reserve of 14.7Mt of high grade rock phosphate (+30% $P_2O_5$) and about 190 Mt of low grade rock phosphate with average of 12% $P_2O_5$. Out of total Indian reserve 217.2Mt, Rajasthan has the largest reserve of rock phosphate of about 78.8Mt.

### Role of Phosphorus

- Phosphorus has great role in energy storage and transfer.
- Phosphorus is a constituent of nucleic acid, phytin and phospholipids.
- It is also an essential constituent of majority of enzymes.
- It is closely related to cell division and development.
- Phosphate compound act as "energy currency" with in plant.
- It stimulates early root development and growth and there by helps to establish seedlings quickly.
- It gives rapid and vigorous start to plants, strengthens straw and decreases lodging tendency.
- It brings about early maturity of crops, particularly the cereals and counteracts the effects of excessive nitrogen.
- It is considered essential for seed formation.
- The supply of phosphorus improves the quality of certain fruits, forage, vegetable, grain crops and increases the disease resistance of crops.
- It enhances the activity of rhizobia and increases the formation of root nodules and there by helps in fixing atmospheric nitrogen.
- Excess of phosphorus may cause deficiency of certain micronutrients (Zn, Fe).

### Pathways of Phosphorus Loss from Agriculture

Phosphorus loss from agriculture can come from-

- Point sources: waste water from farms and dairies and seepage from manure piles.
- Non-point sources: diffuse sources like soil erosion, surface runoff and drainage.

When excesses quantities of slurries and manure are applied to soils and this is followed by heavy rain, surface runoff may occur. During periods of heavy rainfall, water flowing over the soil surface carries eroded particles. When the rainfall is less intense, it percolates into the soil and excess leaches downwards carrying soluble substances with it.

### Strategies for Enhancing P Use Efficiency

There are many approaches of P management may be different in P rich soils such as in developed countries and in poor soils.

- Choice of fertilizer: phosphorus fertilizers are divided into water soluble, citrate and acid soluble groups. When water soluble phosphorus is added to soil, part of it taken up by the plant and the rest quickly become fixed in less available forms as the reacts with soil component.

- Soil test based P application: soil testing is a must for optimizing the use of P and obtaining economic yield of crops on agriculture soils. Fertilizer/ manure P rates on soils with medium phosphorus value need to be sustained for higher crop productivity. In low available P and high responsive soils, adequate P greatly increases crop yields. However, on soils with very high P, a small maintenance dose of P may be sufficient.
- Phosphorus placement: banding is advantageous where soil test levels are low.
- Fertigation: Fertigated single super phosphate (SSP) enhanced the grain yield significantly over broadcast, while Fertigated di-ammonium phosphate (DAP) did not affect it significantly. Phosphorus uptake, P use and agronomic efficiency were higher in fertigation than broad casting.
- Residual P utilization: the studies conducted at Jabalpur showed that Vertisols with high to very high available P might support two rotation of soybean – wheat without P application. After two rotations the available P may decline to below critical limit and fresh application of recommended dose of P is needed.
- Utilization of insoluble P sources or plant and microbial strategies

### Pools of Phosphorus in Soil

- Solution P
- Active P
- Fixed P

These are the three main pools of phosphorus in soil. The solution P pools are very small; usually contains only a fraction of a kg of P per hectare. The solution P is usually be in the orthophosphate form, but small amounts of organic P may exist as well. At growing crop would quickly deplete the P in the soluble P pool if the pool is not continuously replenished. The active P pool is P in the solid phase which is relatively easily released to the soil solution. As plant taken up phosphate, the concentration of phosphate in solution is decreased and some phosphate from the active P for crops. The active pool is the main source of available P or crop. The active P pool will contain inorganic phosphate that is attached on active sites on the surfaces of soil particles. The fixed P pool of phosphate contains inorganic phosphate compounds that are very insoluble and organic compounds that are resistant to mineralization. Some slow conversion between the fixed P pool and active P pool always occurs in soils.

## 7. BIOTECHNOLOGY

# DNA Barcoding - A Rapid and Reliable tool for Insect Species Identification

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### Introduction

One of the biggest challenges facing the world today is ensuring food security. Invasive and developing pests are just one of the many variables threatening agricultural productivity. The first and most important step in deciding the best course of action for managing such invasive pests is accurately identifying them. Pest identification has historically relied on morphological diagnosis from taxonomic research. Accurate taxonomy demands specific skills that can only be obtained via lengthy experience, making taxonomists and trained technologists the only experts who can recognize taxa with accuracy. Accurate species identification has become more and more crucial as the fields of ecology, evolutionary biology, agriculture and economics whereas among others its have grown more interested in biodiversity.

Nonetheless, there are far fewer taxonomists and other identification specialists now. As such, more precise and alternative identification techniques that are accessible to non-specialists are needed. The use of molecular data rather than morphological data to identify taxa is one of the most promising methods; this has long been a core concept among biologists (Blaxter 2003). Advances in DNA sequencing technologies have enabled researchers studying biodiversity to conduct simple, cost–effective and rapid DNA analyses. This progress in biotechnology and the taxonomy crisis itself, played a large role in the creation of DNA barcoding (Jinbo *et al.*, 2011).

After 250 years of Darwin and Linnaeus, a new method called DNA barcoding, a tool of DNA-based taxonomy is in current use to identify known and unknown species on the basis of the pattern of nucleotide arrangement in a fragment of DNA of a particular species. Several researchers have suggested the use of DNA barcoding in taxonomy as a method to achieve rapid species descriptions in the context of the current biodiversity crisis. DNA barcoding is the use of a short standardized DNA sequence (in insects, a 658 bp) fragment of the mitochondrial cytochrome c oxidase (COX I) gene to identify and assign unknown specimens to species besides facilitating the discovery of new species. Wilson (2012) found that barcodes library gain their value due to an intimate association, through voucher specimens from where they came, with other data, particularly, Linnaean names, collection localities and morphology in the form of digital images. This tool is widely accepted all over the globe from hard-core taxonomists' to graduate molecular biologists. In the recent past, due to the rapid development of techniques in molecular biology, nucleic acid sequencing and analysis of large data, the mtDNA study is becoming more popular. Compared to nuclear markers, mitochondrial markers are more susceptible to the effects of genetic drift (Filipova *et al.*, 2011). As a powerful and widely used molecular marker, mtDNA has been applied in many organisms to determine the genetic variations and structure of population. Mitochondrial DNA has become a major tool of comparative genomics and occupies a significant role in genetic structure of population and molecular variations as it is maternally inherited with no intermolecular genetic recombination with rapid rate of evolution. COI is a protein-coding gene in mtDNA. Due to fast evolution, high polymorphism, easy amplification and sequencing, it has shown valuable information and is a widely used genetic marker for population genetic studies especially intra-specific analysis. Regularly and frequently application of insecticides led to modification and development of genetic resistance by means of genotypic variations in major insect pests. Therefore, necessary to explore the genotypic variations that occur within the population of a species to design and formulate effective insect pest management programmes(Fig .1) .

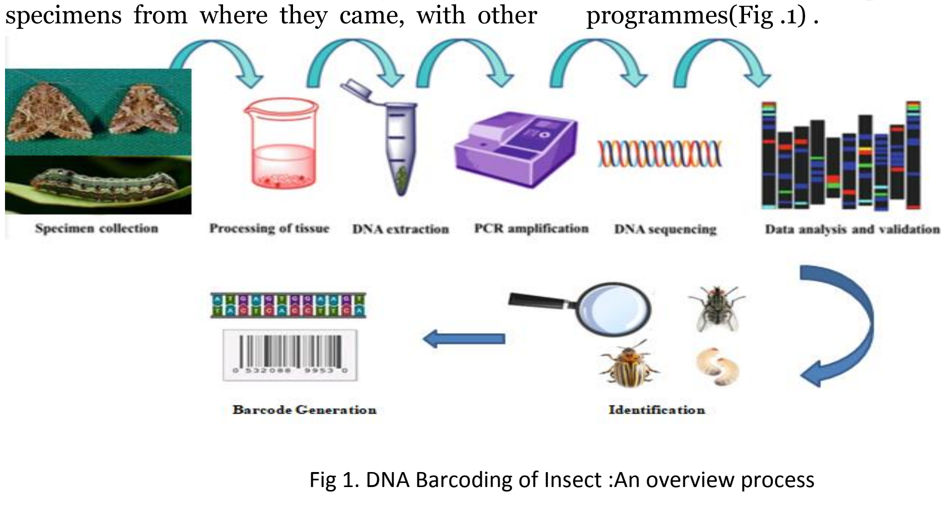


Fig 1. DNA Barcoding of Insect :An overview process

## Why CO-1 Selected as Standard DNA Barcode?

Efficiency in discrimination among the different animal groups and high competency for species identification are the features of standard DNA barcode CO-I. This universal primer can be applied to all animal phyla which were originally designed for marine invertebrates. A 648-bp fragment has sufficient information and can be directly sequenced with a sequencer. The alignment procedure is not strenuous because this is a protein-coding region. The errors can be diagnosed by checking whether the obtained sequence is translatable. These are the reasons why the CO-I region was selected as the standard DNA barcode. Hence, DNA barcoding can be a simple but potent tool for non-experts, especially those who customarily identify a large number of samples. DNA barcoding is gaining attention for identification of taxonomically difficult species concisely. It is a taxonomic method that uses mitochondrial COI gene which is a short genetic marker in an organism's DNA in order to identify a particular species (Hebert *et al*., 2003). Comprehensive molecular information on insect pests and natural enemies of cucurbit crops is very limited as India has generated a total of only 4.6% barcodes of known species with its contrast to an approximate of 59,000 described insect species. On the other hand the corresponding global scenario is about 16% of described species, therefore a lot of emphasis is required to catch up with the world scenario (Jalali *et al*., 2015).

## Usefulness of DNA Barcoding

The access to a public reference database of taxa helped in the accurate taxonomic identification of a wide range of species. Thus, DNA barcode can support various scientific domains (e.g. conservation biology, evolutionary biology, *etc*). DNA barcoding helps to recognize, detect and trace dispersal of patented organisms in biotechnology, either to verify the source organism (e.g. truffles,) or assure intellectual property rights for bioresources. Molecular data can be rapidly retrieved by using DNA barcoding. However, there is a huge discrepancy for morphological tools, in addition to this it can be time-consuming and in some instances totally confusing (e.g. earthworms).

For determining the taxonomic identity of damaged organisms or fragments of (e.g. goods, food and stomach extracts). The DNA barcoding tool is likely to be useful in the food industry, forensics and in preventing illegal trade and poaching of endangered species.When there no other means to match adults with immature specimens molecular characterization is necessary (e.g. *Coleoptera*,). When morphological traits fail to discriminate species then DNA barcoding is the only option available (e.g. field-collected mosquito specimens. DNA barcoding as a species identification tool not only attracts the non-specialists but also attracts specialists.To achieve the CBOL objectives, species need to be taxonomically characterized before their deposit in BOLD, which helps researchers to resolve analytical, technical and fundamental issues beforehand. Taxonomy, molecular phylogenetics and population genetics can be brought together and complemented by DNA Barcoding. DNA barcoding can be treated as a 'formidable tool' to expedite species discovery and species description. Other than as a identification tool of species, DNA barcoding has been applied to solve many complex ecological phenomena. DNA barcoding is emerging as a simple and very reliable tool for studying host-parasitoid interactions and to establish the host range of phytophagous insects which has changed the perspective of many food webs. Its shown potential as incontestable identification tool for biosecurity purposes with global application and also being utilised to document the biodiversity of past and present with reasonable efficiency.

## Limitations of DNA Barcoding

- **The under-described part of biodiversity:** The shortage of samples across taxa will lead to 'barcoding gaps', so sampling quality should be considered with the utmost care during the database construction phase. The selected sample should represent and cover the major part of the existing biodiversity.
- **Inherent risks due to mitochondrial inheritance:** The

mitochondrial DNA (mtDNA) is maternally inherited so its diversity is strongly linked to female genetic structure. The usage of mitochondrial loci can lead to exaggerate sample divergence and make conclusions about the species status unclear. In Lepidoptera, mtDNA polymorphism is structured according to the host plants on which females feed, and the two clades obtained by phylogenetic analyses are artefacts of female nutritional choice.

- **Nuclear Copies of COI (NUMTs):** A translocation of any type of cytoplasmic mitochondrial DNA into the nuclear genome of eukaryotic organisms is known as Nuclear copies of COI. In different species, NUMTs differ in both number and size. Disturbance due to NUMTs must be seriously considered, in both DNA barcode library construction and further specimen identification.
- **Rate of Evolution in COI:** The rate of genome evolution (mitochondrial or nuclear) is notequal for all living species.The rate of evolution can vary at the ordinal level e.g. dermapteran.
- **The Intra-Specific Geographical Structure Should be Taken into Account:** If ignored the species geographical structure, it can distort speciesdelineation. Intraspecific divergence canobtain from geographically isolated populations. Hence, it must be taken into account while setting up the DNA barcode reference database.
- **Barcoding for Biosecurity:** Biosecurity is emerging as one of the most important issues facing the international community. Traditionally it has been associated with risks from infectious diseases, living modified organisms and biological weapons. Globally as many as 80% of the endangered species are threatened and at risk due to IAS (Mandal, 2011). Several studies demonstrate the efficacy of DNA barcoding as applied to invasive species detection and determination of native provenance, including work on agromyzid leafminers, siricid wasps, ants, true bugs, the cactus moth, the European poplar shoot borer and nocturnal moths (deWaard *et al.*, 2010). The rapid and accurate identification of invasive species is indispensable in terms of biosecurity being perceived as the most serious threat to biodiversity. For this purpose, global coverage in the DNA barcode library is of great value.

## Conclusion

Species identification using short DNA sequences will become more reliable when mtDNA based barcode supplements nuclear barcodes. It will reduce the dependency on a single character. It is also help to identify in cases where mtDNA behaves differently to nuclear genes. Molecular phylogenetic studies routinely make use of multiple nuclear genes, so it is not a novel idea. In spite of limitations of DNA barcoding, the reported success using barcoding in differentiating species from taxa and to reveal cryptic species is remarkable. Thus, effort should be made to develop nuclear barcodes which can complement mt-DNA based barcodes. DNA barcoding solely cannot help in accurate identification and description of a species. Therefore, Integration of DNA barcoding, morphological and ecological studies will help in achieving accurate identification and description of a species. DNA barcoding has great potential as a species identification tool because it is practical and affordable to perform and, more often than not, shows species-level separations. Currently, efforts are on to barcode all major groups of animals including insects and millions of species have been barcoded.

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## 8. SOIL SCIENCE

# Role of Phytoliths (Silica) on Growth and Development of Crop

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### Introduction

Phytoliths are produced as a result of biological and physical processes in certain plant groups and deposited as solid silica in intercellular or extracellular locations after absorbing silica in soluble form as monosilicilic acid ($H_4SiO_4$). The term “phytolith” was proposed by Ruprecht (1866). It is composed of two Greek words “phyton = plant” and “lithos = stone” meaning plant stone. This term has been used to indicate all forms of mineralized substances deposited in higher plants, be they siliceous or calcareous in nature.

Numerous other terms have also been used for silica bodies found in plants, such as “opal phytolith”, “plant opal” and “opaline silica”. The term opal has been used because of the color of the particles in reflected light. Phytoliths, like mineral opal deposited by geological processes, are not crystalline in structure. They are amorphous (non-crystalline) and have variable water content. Phytoliths are also put under a more generalized term, as “biogenic silica” or simply “bioliths”. These are all-inclusive terms for silicon found in plants and animals. They help to distinguish silica derived from living system from the silica of inorganic, mainly pedogenic origin. The plant does not use the silica for any of its metabolic processes and so deposits it as a siliceous gel within cavities in its own structure. This gel, on increasing concentration and desiccation, gradually crystallizes into a solid, silt sized particle. Some of the enclosing cell material may be trapped inside the phytolith as it crystallizes. When the plant dies and decays, the phytoliths are released into the soil undergoing the same erosion, transport and depositional processes as other sedimentary particles. Due to the variety of cell types within a plant, phytoliths are formed in a multitude of shapes and sizes depending on the location of deposition and the age of the plant. Phytoliths have been extracted from many different plant organs, including leaves, stems, inflorescence (flowers), seeds and roots. Phytoliths can take shape of readily recognized cells, for example, hairs of stomata, bilobate or cross forms.

### Chemical and Physical Characteristics of Phytoliths

Phytoliths are often referred to as “plant crystals” when, in fact, siliceous secretions are composed mainly of amorphous (noncrystalline) silicon dioxide ($SiO_2$) with varying amounts of water, usually ranging from 4% to 9%. Early researchers established that phytoliths contain small amounts of Al, Fe, Mn, Mg, P, Cu, N, and organic C, ranging from <1% to about 5% of total phytolith weight. These elements are present in the cytoplasm of living cells and then retained when cells become impregnated with solid silica, becoming encased within the phytolith. The carbon in phytoliths is a suitable material for radiocarbon dating using conventional radiometric methods or accelerator mass spectrometry (AMS). Stable carbon, oxygen, and hydrogen isotope ratios can also be directly determined from modern and ancient phytoliths, and carbon stable isotopes have so far been shown to be especially useful in deciphering past vegetation and climate. Biogenic silica of plant origin is optically isotropic, ranges in refractive index from 1.41 to 1.47, has a specific gravity from 1.5 to 2.3, and ranges in color under transmitted light from colorless or light brown to opaque.

## Physiological Role of Silica (Phytoliths) in Plants

Arnon and Stout (1939) observed that inspite of the high silicon accumulation in plants (its amount may equal concentration of macronutrient), until now it has not been considered as an essential element for higher plants according to the criteria of essentiality. Silicon is recognized as a beneficial element for plants growing under biotic and abiotic stresses, for example heavy metal, drought, salinity and pathogens. The beneficial effects of silicon have been observed on growth, development, and yield and disease resistance in wide variety of plant species. Si fertilizers are routinely applied to several crops including rice and sugarcane to enhance high and sustainable crop yields.

## Phytoliths Effect on Growth and Development of Crop

Silicon is an indispensable element for the normal growth and development of some plant species. Examples include horsetails or scouring rushes (*Equistem*), rice (*Oryza sativa*) and beets (*Beta vulgaris*). Negative effects of silica poor growth medium can be dramatic. For example, shoots of equistem, a heavy silica accumulator, collapsed when grown in a silca-free medium.

Silicon has been found to provide structural rigidity to plant parts and hence increasing light interception and energy manufacture, for example, rice leaf blades are more erect silica slag's are applied, allowing more light to reach the lower leaves and substantially increasing the photosynthetic activity. Silica deposited in epidermal cells may act to reduce the rate of transpiration in leaves thereby improving water use efficiency. Silica may help to maintain rigidity in stems and linear leaves, although leaf stiffness may also be related to the degree of lignifications. Silica has been shown to improve the lodging resistance in wheat.The mechanical strength of plants enabling them to achieve and maintain an erect habitat conductive to light interception resides in the cell wall.

The incorporation of silica into cell walls has at least two energetically positive effects. First, the role of silica is analogous to that of lignin in that it is a compression-resistant structural component of cell walls. Second, the erect habit and the disposition of the leaves of plants amply supplied with Si favour light interception and, hence, photosynthesis. A good physiological reason that why plants might want to make phytoliths has recently been brought to the force. Silicon dioxide may ameliorate the toxic effects of aluminium and other heavy metals, such as manganese on plant growth. A number of experimental studies indicate that the addition of silicon in growth medium mitigates the damaging effects of aluminium and manganese on plant growth. A co-deposition of solid silica and aluminium in and around plant cells has been demonstrated for a wide variety of species and plant organs; hence, the mechanism for detoxification may be sequestration of aluminium by silica. Moreover, it now clear a number of benefits to growth and reproduction that appear to be directly related to the presence of silica in either a soluble or a solid state. All the above debate suggests structural and physiological functions of phytoliths.

## Phytoliths Effects during Biotic and Abiotic Stress

Silica is able to protect the plants from multiple biotic and abiotic stresses. Number of studies has shown that silica is effective in controlling diseases caused by both fungi and bacteria in different plant species. Most of the plant silicon occurs in the epidermis, which might dislodge young larvae before they can establish in the stem. Various studies have demonstrated that silicon increases the hardness of plant tissue, which negatively impacts insect larval boring and feeding ability.

Application of silicon to crop plants not only increased the yield but also showed a marked reduction in the incidence of grain discolouration. The discolouration is the result of infection of husks by several fungi. In a subsequent investigation a number of rice disease organisms were identified. Application of silicon to the soil reduced the severity of all diseases identified; different rise genotypes responded to various degrees. Recently, a parallel mechanism as that seen in the resistance of plants to diseases via activation of the plant's own defense mechanisms by soluble silicon has been observed for insect pests.

In addition, metal toxicity, salinity, drought and temperature stresses can be alleviated by silicon application and the means by which silicon exerts these protective effects is still under investigation.

The aluminium toxicity is found to decrease on increasing Si in the nutrient supply to cotton, maize, soybean and barley. aluminium oxides, either added or already present in the soil, also reduce the availability of Si for plant uptake; a situation occurring naturally in heavily weathered and/or acidified soils. A deficiency of Si causes an increased uptake of Manganese and Iron in rice, barley, rye and ryegrass causing toxicities. Application of Si fertilizers relieves this toxicity. The proposed mechanism may be increased oxidation of Mn at the root surface if there is sufficient oxygen present, and redistribution of Mn to prevent necrosis.

The mechanism responsible for plant resistance to water stress and a possible role of Si in these processes may be considered at different levels (molecular, cellular, whole-plant). Essential features of plants response to water stress are following: i) maintenance of homeostasis, including ionic balance and osmotic adjustment, ii) counteraction to damages and their prompt repair, e.g. elimination of reactive oxygen species (ROS) and prevention of oxidative stress, iii) detoxification of excess salts under salinity, iv) regulation and recovery of growth.

### Functions of Phytoliths in Soil

- Increase the silicon availability to plants.
- Activity of heavy metal concentration reduced.
- Helps in storage of carbon (carbon Sequestration).
- Helps in archeological find outs.

### Conclusion

Phytoliths can be considered as a major Si reservoir in the soil and contribute slowly, but significantly to the available Si pool in the soil. Maintain or increase Si availability in the soil to maintain yield in crops like rice, wheat and other Poaceae family plants, for which application phytoliths (crop residue compost) offers an option. Also, that application of crop residue compost (phytoliths) increased total-C in the soil, suggesting that phytoliths are effectively used in the recycling of Si and carbon sequestration in soil.

## 9. ENTOMOLOGY

# Entomophily- Air Pollution and It's Interaction

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### Abstract

Insect pollination is essential to the reproduction of obligate plants. Numerous causes, including pressures imposed by humans, such as habitat loss, increased pesticide use, and climate change, pose a threat to our pollinating insect species. Critical increases in air pollution have also been caused by anthropogenic activities. Air pollution is a lesser-known hazard that can affect insect

pollination. It can cause mismatches between flowering and pollinator activity, alter the way pollinators are attracted to flowers, or prolong the foraging season. By addressing pollinator fitness and the threat that air pollution poses to plant and pollinator groups, we can gain a deeper understanding of the role that air pollution plays in contributing to global change.

## Introduction

Insects are important pollinators that support the populations of wild plants and provide human food security by visiting a vast array of cultivated and wild plants. The crucial ecosystem service of insect pollination is in danger due to declines in pollinator richness. However, the use of pesticides in agriculture, the destruction and degradation of suitable habitat, and the fall in the diversity of floral resources are the main causes of the global decline in insect pollinator populations, which can be attributed to human actions. It's also believed that pollinator richness and abundance are impacted by climate change, both directly and indirectly through interactions with other drivers of global change (Potts *et al.*, 2010; Ganuza *et al.*, 2022). The quality of the air has significantly declined as a result of anthropogenic activity, and air pollution is still rising globally. In return for collecting floral rewards (usually in the form of pollen or nectar) for their own sustenance, that of their brood, and in some cases that of their entire colony, pollinators transfer pollen between flowers or flower parts, a process that is beneficial to the reproduction of many flowering plants. Pollination is a mutualistic relationship (Duque and Dewenter, 2024). There are facultative as well as obligate plant-pollinator interactions. Plant–pollinator interactions are essentially dependent on the occurrence of entomophilous plants and insect pollinators, their synchrony and attraction, pollinator orientation, and the quality and quantity of floral rewards provided by plants. These factors can also have an indirect impact on plant reproduction and pollinator abundance, which in turn affects future interactions. We summarize here the state of our understanding on the effects that air pollution can have on each of these factors.

## Synchrony

Insect pollination is only possible when there is phenological overlap between entomophilous plants and their insect pollinators (Schenk *et al.*, 2018). Although the effects of air pollution on insect phenology have not been thoroughly studied, there is evidence that caterpillars exposed to smoke (Tan *et al.*, 2018) and caterpillars fed plants exposed to high concentrations of ozone (Jondrup *et al.*, 2002; Khaling *et al.*, 2015) experienced delayed growth. Plants and their pollinators may not match in time as a result of phenological changes (Gerard *et al.*, 2020).

## Visual Cues

During foraging, pollinators employ visual cues such as floral color, size, and shape to identify flowers (Dafni and Kevan 1997; van der Kooi *et al.*, 2019). A modeling approach suggests that these changes in reflectance induce a partial change in the color perception of butterflies and flies, but not bees. In *Erodium paularense*, even current levels of ozone appear to be high enough to reduce petal size, modify petal reflectance, and alter the anthocyanin reflectance index therein (Prieto-Benitez *et al.*, 2021).

## Chemical Cues

Pollinators are typically drawn to a particular plant chemically by volatile organic compounds (VOCs) released and produced by the plant's flowers. When flowers are ready for pollination, floral VOC emissions are usually higher (Muhlemann *et al.*, 2014). As demonstrated by other plant volatiles, air pollution may have an impact on the synthesis of these secondary metabolites or may react with them once they are released into the atmosphere (Blande *et al.*, 2014). When floral VOCs in tobacco (*Nicotiana alata*) were exposed to high ozone levels, some of the VOCs' quantities reduced and new reaction products developed, were changed (Cook *et al.*, 2020), volatile ratios were impacted when the plant was subjected to ozone fumigation during volatile collection or when the pollutant was applied to the floral VOC blend instead of the plant (Dubuisson *et al.*, 2022).

## Detection of Floral Volatiles

The usage of electroantennography has

been employed to evaluate if ozone impacts pollinators' sense of smell from flowers. Western honeybee antennae exposed to 1000 parts per billion (ppb) of ozone were found to respond differently to specific volatiles (Dotterl *et al.*, 2016). Antennal responses changed in response to ozone exposure in both the buff-tailed bumblebee (*Blastophaga psenes*) and the fig wasp (*Blastophaga psenes)* (Vanderplanck *et al.*, 2021); these changes depended on the VOC examined, ozone concentration, and length of exposure to the pollutants.

## Olfactory Learning and Memory

Pollinator cognition may be compromised by exposure to air pollution, which could have an impact on memory and learning. Demares *et al.* (2022) found a significant detrimental impact on memory and olfactory discrimination in western honeybees exposed to ozone, along with a little reduction in learning capacity both immediately following exposure and following a period of rest. According to Leonard *et al.* (2019), diesel exhaust exposure had a detrimental impact on the learning and memory capacities of western honeybees as well, with an effect size that was independent of pollutant concentration.

## Orientation

Some pollinators have evolved the ability to employ patterns of polarized light to orient themselves to their destination, allowing them to travel great distances in pursuit of rewarding blooms (Beekman and Ratnieks 2000). Pollinator orientation can be hindered by elevated atmospheric PM concentrations, though, as polarization might be impacted. Western honeybee foraging trip duration rose by 71% on average during a dust storm compared to the pre-event period, and foraging time did not return to pre-event levels even after the storm passed (Cho *et al.*, 2021).

## Quality and Quantity of Floral Rewards

An abundance of nutrient-rich pollen and nectar is essential for the health and vitality of an insect pollinator as well as the fitness of their progeny. Stabler (2016) observed that ozone treatment of broad bean (*Vicia faba*) plants resulted in favorable effects on nectar volume, sucrose and non-essential amino acid concentrations, and negative effects on pollen weight and the concentrations of free and protein-bound amino acids. Based on these findings, Duque *et al.* (2021) proposed that improved nectar quality and quantity could potentially be the cause of western honeybees' longer flowering period on ozone-exposed charlock mustard plants.

## Pollinator Fitness and Reproduction

The energy balance is changed in such a situation, which is detrimental to pollinator fitness. When giant Asian honeybees (*Apis dorsata*) were collected in Bangalore, southern India, at locations with extremely high concentrations of PM10 (PM with a diameter of 10 µm or less), they showed altered circulatory physiology, elevated expression of genes related to stress, and decreased survival rates when compared to honeybees collected at less polluted sites (Thimmegowda *et al.*, 2020).

## Population and Community Dynamics

The effects of air pollution on plants vary depending on the species, and plant susceptibility to these contaminants is very diverse. Pollution-tolerant species have a competitive advantage over pollution-intolerant ones in the presence of air pollution, which can have an impact on species coexistence and community assembly (Martinez-Ghersa *et al.*, 2017; Stevens *et al.*, 2020).

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## 10. ENTOMOLOGY

# Microbial Degradation of Insecticides

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## Abstract

Pesticide is any substance that can destroy, diminish, prevent, repel, control, attract, or even kill a pest or non-target organism. Notwithstanding their potential effectiveness, they may potentially be harmful to the environment and public health because of their low biodegradability and toxicity. Since it might lessen the harmful effects of pesticides, pesticide biodegradation is significant. A wide variety of microorganisms, such as bacteria, fungi, and algae, are capable of breaking down pesticides. Through a variety of metabolic routes, microorganisms can bioremediate pesticides, with enzymatic degradation being a key factor in the chemical transformation of the pesticides.


## Introduction

Pesticide refers to any material or combination of materials designed to prevent, eliminate, or manage any type of pest, such as insects, arachnids, or other vermin that may harm crops, animals, or people, or that may interfere in the production, processing, storage, transportation, or marketing of food, agricultural products, wood, wood products, animal feedstuffs, or materials that can be given to animals to control vermin, insects, or other pests in or on their bodies (Carles *et al.*, 2021). Agricultural usage of pesticides dates back at least eight decades, and dichloro-diphenyl-trichloroethane (DDT) was the first pesticide ever developed. Over the past few decades, there has been a rise in the use of pesticides. When comparing the use of various pesticides from 1990 to 2016, the tendency of more tons per year becomes evident. This trend continued steadily increasing from 2016 to 2021 (Guerrero Ramírez *et al.*, 2023). Finding strategies to lessen the effects of pesticides is a continuous endeavour because of its detrimental effects on non-target species and the environment. Microorganisms can adapt and grow in a variety of situations thanks to their remarkable metabolic plasticity. Microorganisms are a useful tool for the restoration of both soil and water because of this and other characteristics. Moreover, its application typically costs less than that of chemical and physical procedures (Huang *et al.*, 2018). Microorganisms are a useful tool for the restoration of both soil and water because of this and other characteristics. Furthermore, using them is typically less expensive than using chemical and physical approaches (Raffa *et al.*, 2021). Fungi, bacteria, actinomycetes, and algae are among the wide range of microorganisms that may break down pesticides, these organisms can obtain nutrition from xenobiotic chemicals.

## Biodegradation of Pesticides

Microorganisms possess an exceptional ability to adjust to the ever-changing conditions of their surroundings, such as mutations or inductions. These xenobiotic substances will be metabolized by microorganisms via a variety of metabolisms, which they can then use as a source of energy, nitrogen, phosphorus, carbon, and other elements (Matsumura *et al.*, 1982). The pesticides' microbial metabolism can either mineralize or completely biodegrade the compounds, in which case the majority of the byproducts are appropriate for reintroduction into the environment (Table.1).

### *Bacteria*

The metabolic machinery to break down pesticides is shared by several bacterial genera. Pesticide molecules may be utilized as nutrients or as electron donors in this process, the rate of metabolism will be influenced by a number of biotic and abiotic factors, including temperature, the availability of water and nutrients, the presence of other microorganisms, and the physical disturbance of soil caused by agricultural practices (Maqbool *et al.*, 2016). Ultimately, a highly dangerous material is changed into a less harmful or even non-toxic product by the bacterial pesticide biodegradation process.

### *Fungi*

Fungal growth allows for the production of extracellular enzymes in sufficient quantities to provide the enzymes required for bioremediation, which is why they are more commonly used for bioremediation in soil than in water (Gouma *et al.*, 2014). One of the primary agents for soil bioremediation against xenobiotic chemicals is basidiomycetes. Their bioremediation technique, which is based mostly on the synthesis of extracellular ligninolytic enzymes, is distinguished by a high capacity for degradation. This process reduces complicated molecules to simple ones and generates energy and nutrition from the toxins.

***Algae***

Effluents contaminated with heavy metals, pesticides, or organic matter can be converted by algae into a source of nitrogen (N), thereby removing excess nitrogen from the environment. As a result of their metabolic adaptability, algae are effective bioremediation agents for contaminated water, whether it originates from the industrial, residential, or agricultural sectors (Lutzu *et al*., 2021). They are also capable of producing oxygen (O2) and sequestering carbon. In order to accomplish the bioremediation of pesticides present in water, it might form connections with heterotrophic bacteria.

***Actinomycetes***

The ability of actinomycetes to metabolize xenobiotic compounds from soil and water is well-established. Pesticides are a carbon source that actinobacteria, such Streptomyces, can use to totally break down inorganic chemicals and make them non-toxic to the environment (Briceno *et al*., 2018). To accomplish bioremediation processes, streptomycetes can use a variety of metabolic strategies, including the synthesis of enzymes including hydrolases, glucosyltransferases, xylanases, laccases, and proteinases.

**Table 1. Insecticides degrading micro-organisms**

| Microbe | | Insecticide | Reference |
|---|---|---|---|
| Bacteria | Lactobacillus plantarum<br>Chryseobacterium<br>Variovorax<br>Aeromonas<br>Xanthobacter<br>Acidovorax | DDT,<br>Lambda cyhalothrin,<br>Permethrin,<br>Chlorpyrifos, Dimethoate, | Yang et al., 2005<br>Yasmin et al., 2022<br>Dar et al., 2022 |
| Fungi | Trichoderma sp.<br>Byssochlamys spectabilis<br>Verticillium sp.<br>Aspergillus sp,<br>Trametes versicolor | DDT,<br>Lambda cyhalothrin,<br>Permethrin, Chlorpyrifos,<br>Dimethoate,<br>Carbofuran | Purnomo et al., 2020<br>Kumar et al., 2022,<br>Fu et al., 2016 |
| Algae | Chlorococcum sp.<br>Chlorella sp. Scenedesmus sp.<br>Chlorella vulgaris | DDT<br>Chlorpyrifos<br>Carbofuran | Avila et al., 2021,<br>Hussein et al., 2017 |
| Actinomycetes | Streptomycetes | organochlorines,<br>organophosphates, pyrethroids | Briceno et al., 2018 |

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## 11. AGRICULTURAL ENTOMOLOGY

# Huanglongbing (HLB) Dsease of Citrus (Greening) and Its Vector Asian Citrus Psyllid, *Diaphorina Citri* Kuwayama (Homoptera: Psyllidae) – an Outlook

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### Insect pests of citrus

A plethora of 823 insect species (Ebeling, 1959; Wadhi and Batra, 1964) were reported on citrus and jeopardized to citurs cultivation all over the world. Buker and Manner (2006) reported that citrus trees are affected by numerous species of insects pests, mites, and disease pathogens that infest leaves, flowers, bark, fruits, and branches. The several species of insects pests such as whitefly, *Dialeurodes citri* Ashmead, citrus psylla, *Diaphorina citri* Kuwayama, leaf miner, *Phyllocnistis citrella* Stainton, citrus caterpillar, *Papilio demoleus* Linnaeus, fruit piercing moth, *Ophideres* spp and citrus red scale, *Aonidiella aurantii* Maskell attacking citrus trees were found by Qamar Zeb *et al*. (2011). Among these pests, the most imperative pests is Asian citrus psylla . Since the citrus greening disease is vectored by Asian citrus psylla (Halbert and Manjunath, 2004; Hall, 2005). Moreover, Huanglongbing (HLB or citrus greening) is a bacteria spread by a tiny insect called the Asian Citrus Psyllid. Due to infestation, fruits become bitter and ultimately kills the tree. The disease was first detected in Florida during 2005; citrus greening is major threat found in every commercial citrus-producing county in the state. It is the biggest threat in citrus industry has ever faced, causing production to plummet in recent years.

## Asian Citrus psyllid, *Diaphorina citri* Kuwayama (Homoptera: Psyllidae)

Dorge *et al.* (1968); Bindra (1967) observed that, the psylla is a serious insect pest in Maharashtra, Punjab, Haryana, Himachal Pradesh, Coorg area of Karnataka and and North eastern hilly region in India. During winter, heavy mortality of pest i.e. about from 53 per cent in July to 98 per cent in December, occurs; the eggs fail to hatch and 58 per cent of the hatched nymphs fail to develop into adults (Mangat, 1966). The favourable temperature range is 22-29$^{o}$C and is not found above 1300-1500 m MSL (Aubert *et al.*, 1986). It is most active on spring and after monsoon flushes but winter and temperature nearing 40$^{o}$C is detrimental for their build up. Moderate showers wash away the population. The psyllid nymphs suck the sap from tender shoots and buds. It also excretes honeydew and on which sooty mould grows and causes adverse affect on photosynthetic process of the plants (Sharma *et al.*, 2003). In India, citrus registered 25 per cent yield losses by insect pests, out of which psyllids contributed 83-95 per cent (Shivankar and Singh, 2006). Additionally, Moss *et al.* (2014) estimated more than a billion-dollar loss due to HLB which is transmitted by psyllids. As well, Kenya Agricultural Research Institute reported that whole orchards had been lost due to Huanglongbing (HLB) disease of citrus (greening), while mild infestations caused up to 25 per cent yield loss. Bové (2006) reported the presence of both psyllids and the greening pathogen and recommended production of disease-free nursery plants, increased pesticide usage to reduce psyllid populations and removal of trees with visual symptoms of greening. Psyllids are known to inject toxins while feeding on the flushes which causes die back. Pluke *et al.* (2008) reported that, other than direct feeding damage, it was also an efficient vector of the bacterium, *Candidatus liberibacter asiaticus* which causes greening disease of citrus leading to slow death.

## Life History of psyllid, *D. citri*

The life cycle includes an egg stage, five nymphal instars and adult stage. The average size of egg is 0.31 mm long, 0.14 mm wide elongated and oval in shape. Eggs are light yellow when freshly deposited and bright orange distinct red eye spots at maturity. Nymphs are green or dull orange feed on young leaves and stems. The first nymphal instar is 0.33 mm long, 0.17 wide, second nymphal instar is 0.45 mm long, 0.25 wide, third nymphal instar is 0.74 mm long, 0.43 wide, fourth nymphal instar is 1.01 mm long, 0.7 wide and fifth nymphal instar is 1.6 mm long, 1.02 mm wide and maximum adult longevity as 117 days at 15 °C to 51 days at 30 °C (Tsai and Liu, 2000).

Adults are small (2.7-3.3 mm long) with mottled brown wings. Adults have three relatively distinct abdominal colors (grey/brown, blue/green, and orange/yellow) (Wenninger and Hall, 2008). Adults rest or feed on citrus leaves or young shoots with their bodies held at a 45° angle from the plant surface.

Females can lay eggs throughout their lives if young leaves are present. Adult females typically lay 500–800 eggs over a period of two months, with a maximum of 1900 and adult males live an average of 21–25 days and females live an average of 31–32 days at 24 °C. (Hussain and Nath, 1927; Nava *et al.,* 2007). Mating, oviposition, and other movements are restricted to, daylight hours (Wenninger and Hall, 2007).

Humidity also influences oviposition. Females produce fewer eggs when relative humidity drops below 40% (Skelley and Hoy, 2004). Developmental times of eggs and nymphs vary with temperature: mean development from egg to adult ranges from 14.1 days at 28°C to 49.3 days at 15°C and optimal temperature range for development is 24–28°C and the population generation time at 25 °C is 20–22 days (Fung and Chen, 2006). The lower and upper temperature thresholds for oviposition are 16.0 and 41.6°C, respectively, and most eggs are oviposited at 29.6°C (Hall *et al.,* 2011). But virgin females lived up to 188 days (on average 90 days) at 27 °C on a favorable host plant (Richardson and Hall, 2012). The pest completes 9-10 or even up to 16 overlapping generations in a year (Hussain and Nath, 1927; Khan *et al*., 1989). Adult female psyllids lay eggs on tender new leaf tissues that have not yet expanded. In most environments the psyllid is active throughout the year, although populations may be decreased during colder winter months. The lifecycle is closely linked to the presence of young, tender leaf tissues (flushes) needed for reproduction (Catling, 1970; Rogers *et al*., 2011). (Fig. 1). Thus, increases in psyllid populations are associated with the flushing patterns of citrus trees. (USDA, 2011).

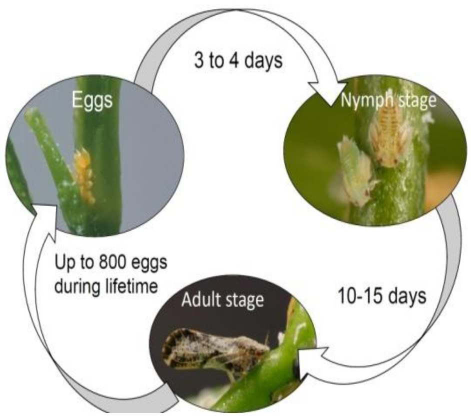


*Fig 1. Lifecycle of Asian citrus psyllid, D. citri*

## Damage Symptom

The late spring or early summer flushes favours and influence the psyllid populations development at higher rates. Mature citrus trees naturally generate three to four major flushes per season. Whereas, Young, non-bearing citrus trees produce many more flushes throughout the season than mature trees. Since young trees are continually producing new flush, these trees are much more attractive to psyllids and thus could become infected with the greening pathogen at a much higher rate than mature trees. Shivankar and Rao (2005) found that, heavy and prolonged flushing coupled with low temperature and high humidity favours psylla occurrence and outbreaks. Because of the extended period of new flush growth on young trees, additional managing tactics are needed to retard psyllids populations on these tree (Rogers and Shawer, 2007). One to two trees infected with greening eventually die within 5–10 years (Siddharth Tiwari *et al.,* 2012 ). The psyllid nymphs suck the sap from tender shoots and buds. It also excretes honeydew and on which sooty mould grows and causes adverse affect on photosynthetic process of the plants (Sharma *et al*., 2003). Moreover, its transmitted disease known as "citrus greening" and the symptoms of includes yellowing veins on leaves as well, new root growth is often suppressed and fruit are often small and may drop from the tree prematurely (Fig 2). Inaddition, citrus greening leads to end with the increases fruit bitterness and distorted fruit shape causes economic losses.


*Fig 2. Citrus greening*

## Conclusion

Management of the vector borne disease is tedious process since by the ubiquitous existence of citrus trees across the region, not only on commercial orchards, but also in backyards as a household fruit crop is a critical thing since it's readily and frequently used in small scale farmers as well as all sectors of peoples in the world. So, eco-friendly approach is the best way and effective option to manage the disease. Hence, disease incidence should be carefully observed and necessary measures should be taken to overcome the spreading of diseases as well as vector.

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