P.G. SEMINAR ABSTRACTS - 2011

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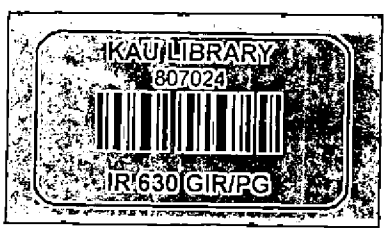

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Forward

The masters seminar is a programme designed with multiple purposes. It introduces the student with the intricacies of selecting a current, promising topic relevant in the concerned discipline, and developing it into a presentable and interesting form to the heterogenous audience. It benefits the academic community of the institution by way of providing a window to a plethora of upcoming topics in science. It hones up the presentation skills of the student, his investigative and analytical capacity and the scientific awareness of the audience, which includes fellow PG students and the faculty members.

The masters seminar is a course that is implemented with utmost care, under the guidance of a team of faculty members as the course teachers. I would like to place on record my appreciation to Dr. D. Girija, Dr. Jayasree Krishnankutty and Dr. S. Nirmala Devi, the seminar course teachers, for their untiring efforts to make the seminar programme of this year a great success.

This is a documentation of the abstracts of the seminars presented in the Masters seminar 2011 which will provide the reader a glimpse into the diverse knowledge areas that were under discussion during the course. References for further reading are provided at the end of each abstract so as to give guidance for the interested person. This can be a valuable on-line repository and E-Learning material which can be launched on-line.

I wish that this compilation will serve as a fresh, wisely chosen compendium of information for the seeker and help kindle in him an undying passion for scientific quest. The collaborative efforts of the RKVY project "Centre for E-Learning" is appreciated for providing funds for the E-material and printed books.

Dr. C.T. Abraham
Associate Dean

Preface

The masters' seminar is a program, defying the mere status of a course, spreading across all disciplines in the College of Horticulture and involving all PG students of one batch. The college has always treated this program with academic diligence, which the Associate Dean himself chairs sometimes. As course teachers we have given our best to this course, right from the scrutiny of the topics suggested by the major advisors through conduct of the program and allocation of marks. A foolproof, democratic approach has been used, to ensure that a student gets evaluated according to merit, sincerity and hardwork and not according to chance.

We hope that this repository and its e-version of the power point slides and full reports will serve to give new ideas and new lines of thinking to many coming batches of students and scientists all over the world. It can serve as a good reference source to students and academicians of all status, as each abstract is complete with a future reference guidelines too, at the end.

With pride and pleasure, we present this compilation before the earnest seeker.

Course Teachers

Contents

DEPARTMENT OF
AGRICULTURAL ECONOMICS

Financial Inclusion

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India is one of the fastest growing economies of the world with a population of over 1.21 billion. Out of this, 72 per cent lives in rural areas and 28 per cent in urban areas. While India is targeting towards a double digit economic growth rate, it is necessary to ensure participation from all the sections of the society. Lack of access to finance for small and marginal farmers and other weaker sections of the society have been recognized as a serious threat to economic progress. Prolonged deprivation of the financial services can even lead to social tensions causing social exclusion. Financial inclusion is considered as an explicit strategy for achieving inclusive growth in the country.

Even though a number of initiatives have been undertaken to address the economic problems of the rural poor, financial inclusion was given a formal policy dimension only in 2005. Financial inclusion is defined as the process of ensuring access to financial services by providing timely and adequate credit to vulnerable groups such as weaker sections and low income groups at an affordable cost. The financial services include savings, loans, payments, remittance facilities and financial counselling/advisory services by the formal financial system. National Sample Survey data revealed that 51.4 per cent of the farmer households do not access either institutional or non institutional credit. Despite the vast network of bank branches, only 27 per cent of total farm households are indebted to formal sources. Apart from the fact that exclusion in general is large, it varies widely across regions, among occupational groups etc (GoI, 2008).

In order to overcome the skewed nature of financial service delivery and to sustain an equitable growth, a committee on Financial Inclusion was constituted by GoI in 2006 under the chairmanship of Dr.C Rangarajan. The committee

recommended that financial inclusion should be taken up in a mission mode with a clear target to provide access to comprehensive financial services to at least 50 percent of financially excluded households by 2012 through rural/semi-urban branches of Commercial Banks and Regional Rural Banks. The remaining households have to be covered by 2015.

Extending financial services to excluded segments of population involves cost. The Committee has therefore, proposed the constitution of two funds, the Financial Inclusion (Promotion and Development) Fund and the Financial Inclusion Technology Fund with an initial corpus of Rs.500 crore to be contributed by GoI, RBI and NABARD.

The RBI initiatives towards financial inclusion are 'no frills' account, simplified KYC norms, General Purpose Credit Cards, Financial Literacy and Credit Counselling Centre, Project Financial Literacy and Business Correspondents. The NABARD initiatives include SHG-Bank linkage programme, Microenterprise Development programme, Joint Liability Groups etc. (Mehrotra *et al.*, 2009).

The problem of financial exclusion is not only for the developing countries alone but for the developed countries as well. But the type, degree and magnitude vary between the two worlds. The effectiveness of financial inclusion is evaluated using the Financial Inclusion Index (FII), which is computed as a weighted average of dimension indices of the indicators of financial inclusion (Sarma and Pais, 2008). India is ranked 29th in the list of 55 countries based on performance in banking penetration, availability of the banking services, and the usage of the banking system.

Financial inclusion assumes greater importance in India as access to finance by the poor and vulnerable groups is a prerequisite for poverty reduction, social cohesion and inclusive growth. Paradoxically, though financial sector policies in India have long been driven by the objective of increasing financial inclusion, the goal of universal inclusion still remains a distant dream.

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Green Accounting

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Only the countries that have devised sustainable means to manage their natural wealth would move up and will remain in the development ladder (World Bank, 2011).

India is one of the fastest growing economies in the world, with an expected Gross Domestic Product (GDP) growth rate of nine percent in the next financial year. GDP is an indicator of economic growth which reflects the total monetary value of goods and services produced in a country during a year. The methods for the estimation of GDP are income method, expenditure method and value added method.

India is rich in natural resources like forests, water, wetlands, minerals etc. The data from different sources indicate that the natural resources are depleting both in terms of quality and quantity. However, GDP as an indicator of economic growth is not reflective of these qualitative components of social and environmental growth. Green Gross Domestic Product (Green GDP) was introduced to overcome the shortcomings of GDP with respect to the case of natural resources. Green GDP is meant to include the value of ecosystem and treat the same on an equal footing with the market economy. It is the environmentally adjusted GDP, which requires measurement of the benefits arising from the public goods provided by nature for which there are no market indicators of value (Boyd, 2006).

The traditional System of National Accounts (SNA) cannot support the estimation of green GDP and hence a modified system of national accounts known as green accounting has been evolved. Green accounting helps to accommodate important

environmental aspects and to construct an integrated indicator of sustainability (Simon and Proops, 2000). The approaches to green accounting are either by creating separate or satellite accounts, or by integrating environmental accounts with the traditional system of national accounts (UNEP, 1997). SEEA (System of Integrated Environmental Economic Accounting) is the internationally accepted green accounting approach which takes into account both the environmental and economic variables.

It was the United Nations Conference on the Human Environment, at Stockholm in 1972 that emphasised the importance of accounting environmental services. Following that, the first Environmental Accounts (EA) was constructed by Norway in 1978. Since then several countries joined the frey trying to evolve appropriate methodologies for the estimation of green GDP. In 2010, the World Bank has launched a new initiative called the global partnership for ecosystem valuation and wealth accounting. It brings together a group of developed and developing countries to test out and implement expanded measures of natural wealth and include these in countries' national accounts. In tune with the global efforts, India is attempting to map its green GDP by the year 2015.

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Contract Farming in India

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The Indian agri-food system is undergoing rapid transformation but an important concern in this context is that while the "front end" activities including wholesaling, processing, logistics, and retailing are rapidly expanding, the "back end" activities of production agriculture have been continuously fragmenting. The challenge lies in linking the two ends by ensuring viable business opportunities for both farmers and agri-business firms and contract farming has proved to be a feasible solution.

Contract farming or marketing is an arrangement between the farmer-producers and the agri-business firms to produce certain pre-agreed quantity and quality of the produce at a particular price and time (Acharya and Agarwal, 2009). The specifications of the agreement are put under eight different headings viz., contract duration, quality standards, production quotas, credit arrangements, crop delivery arrangements, pricing arrangements, payment procedures and insurance arrangements.

Contract farming of crops has existed from time immemorial. It was prevalent in Greece and China in the first century A.D. It gained prominence in British colonies as a means of procuring raw-materials for British industries. It became a major form of commercial agriculture in the US by the end of the eighteenth century. In India, domestic sugar mills entered into contract with sugarcane farmers in the early sixties. The major breakthrough was in the eighties when PepsiCo entered into contract with the tomato farmers of Punjab. Since then, Punjab has been a pioneering state in undertaking contract farming. Farmers in Andhra Pradesh, Tamil Nadu and Maharashtra have been in the forefront for contract farming in poultry, with major poultry integrators such as Suguna, Godrej

Agrovet and Ventakeshwara Hatcheries playing the lead role. Retail ventures led by Reliance, Spencer's and others are procuring their daily requirements of fruits and vegetables through contract farming. Nestle has been one of the major players in the dairy sector for more than four decades now. Global Green Company and Capricon Foods are two companies contracting with farmers to supply processed gherkins in the global market (Gulati *et al.*, 2010). In Kerala, contract farming arrangements are predominant in the medicinal plant sector.

Contract farming is seen by proponents as a way to raise farm income by delivering technology and market information to farmers thereby incorporating them into new remunerative markets. While the farmer enjoys income stability due to assured price, the firms have better access to land and get uniform produce at reduced input costs per unit. Critics, however, see it as a strategy for agribusiness firms to pass production risk to farmers, taking advantage of an unequal bargaining relationship (Singh, 2010). Most importantly, it is the default risk by either party that leads to an unsuccessful contract farming arrangement.

There is no single recipe to make contract farming work in smallholder agriculture. A number of factors, intrinsic and extrinsic to the contract influence the relationship between agribusiness firms and farmers, and therefore the performance and the sustainability of contract farming. The major success criteria include the assurance of premium price and increased profits, legal protection and reduced risk to the farmer (Birthal, 2008). To solve the problems of credit in contract farming, NABARD has introduced a special refinance package.

Clearly, for the proverbial win-win situation, a better institutional back-up along with the strategies for formulating a clear contract farming law is necessary. Farmers have to come to terms with issues like quality and deadlines and companies have to appreciate that man in the fields is signing a contract because he wants to improve the quality of his life.

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Tenant Farming in India: Status and Problems

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Land ownership provides a sense of security to people and it also determines the economic condition as well as social status of individuals. Indian agriculture is predominated by small and marginal farmers and the agricultural scenario is characterized by the incidence of tenancy and landlessness (Sharma, 2010).

Tenant farming is an agricultural system in which the cultivator cultivates a land taken from an owner on payment of rent or by sharing the produce of land with the landlord (Agarwal, 2009). Tenancy reforms refer to all sorts of policy induced changes associated with the pattern of ownership, tenancy and management of land (Appu, 1996). The major objective of tenancy reforms is to "actualize land to the tiller". The three main categories of tenants are occupancy tenants, tenants at will and subtenants.

Before independence, during the British colonial period there existed three main tenurial systems. They were Zamindari system, Mahalwari system and Ryotwari system. Out of the total cultivated area in India, 57 per cent of area was covered by Zamindari system, 38 per cent by Ryotwari system, and only five per cent were covered by Mahalwari system. After independence, there have been many tenancy reforms that were implemented with the aim to protect the original tillers of the land. Those reforms are abolition of Zamindari system, fixation of rent, security of tenant cultivators, right of ownership and ceilings on landholdings. These tenancy reforms had both positive and negative aspects.

According to the status of land leased for farming in India (Kurmanath, 2011), the two states of Tamil Nadu and Bihar have the highest and lowest per cent of leased out land to agricultural labourers respectively. In India as a whole 36 per

cent of leased land is given to landless, 48 per cent is given to farmers having less than 0.5 hectare and eight per cent is given to farmers having 0.5 to one hectare of land.

Tenancy laws are state subject. Hence different states will be having different tenancy laws. In Kerala tenancy laws had been implemented with reference to The Kerala Land Reform (Amendment) Act, 1969 and The Kerala Land Reforms (Tenancy) Rules, 1970. Kerala has been way ahead of the rest of the country in implementing the tenancy reforms (Oommen, 1993).

Some policy recommendations can be made with the view to protect the tenants such as plugging exemptions and escape clauses like revision of resumption of cultivation, removal of "supervision" as personal cultivation, measures to prevent re-emergence of informal tenancy and access to institutional credit.

Contribution of tenancy reforms could not be totally neglected despite their shortcomings. Programmes including tenancy reforms could not bring any significant changes in the redistribution of land. There are large gaps between policy and legislation and implementation.

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DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

House Dust Mites in Human Environment

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House dust mites (HDM) are prevalent in human dwellings in humid geographical areas throughout the world. They have been known to be associated with allergies since 1960s and have become a focus over the years for their involvement in respiratory ailments. They do not bite or sting but harbour strong allergens in their body and constant contact with these allergens can trigger respiratory and dermatological problems in some persons (Chillar *et al.*, 2007).

Dust mites belong to the family Pyroglyphidae of the suborder Astigmata. Thirteen species of dust mites have been identified in house dust, of which four are very common in homes worldwide and are the major sources of mite allergens. They are *Dermatophagoides pteronyssinus*, *D. farinae*, *Euroglyphus maynei* and *Blomia tropicalis* (Arlian and Platts-Mills, 2001). Dust mites feed on organic detritus such as flakes of shed human skin and flourish in the stable environment of human dwellings. HDM are 70 to 75 per cent water by weight and they obtain and maintain their water balance primarily by absorbing water from air. They prefer a higher humidity of 75 to 80 per cent and a constant warm temperature of 25°C (Arlian *et al.*, 1999).

Allergens responsible for initiating the allergic reactions are present in mite bodies, saliva and faeces. Mite allergens are divided into specific groups on the basis of their biochemical composition and molecular weight. Group 1 allergens (Der p1, Der f1, Eur m1 and Blo t1) are glycoproteins and they originate from cells lining the intestinal tract of mite. Group 2 allergens (Der p2, Der f2, Eur m2 and Blo t2) are non-glycosylated and are associated with secretions from male mite reproductive tract (Arlian and Platts-Mills, 2001).

Sensitization to house dust allergens is strongly associated with four diseases: perennial rhinitis, atopic dermatitis, asthma and allergic conjunctivitis. Nelson *et al.* (1996) have proposed the allergen levels that represent a risk factor for sensitization and asthma. In genetically predisposed individuals an exposure to two microgram of Der p1 per gram of dust can be considered as major risk factor for sensitization and ten microgram of Der p1 per gram of dust for asthma.

Allergic diseases due to HDM can be managed by avoidance of dust mites, medical treatment and immunotherapy with mite allergens. Interventions for reducing mites and mite allergen levels in homes should have three interrelated goals *viz.*, reduce live mite population, reduce mite allergen levels and reduce human exposure to both.

Complete elimination of dust mites in a home may not be possible but their number can be tremendously reduced through a combination of management strategies. By this, humans can ensure non-sensitization to mites and keep themselves free of dust mite allergy.

"Make your home free of dust mites and don't let them make a nest out of your home."

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Vision and visual navigation in nocturnal insects

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The visual communication systems of insects are remarkably sophisticated. With the help of visual sensors such as compound eyes, insects recognize and react to conspecific individuals, avoid predators, locate food sources, intercept prey, navigate to and from nest sites, and walk, swim or fly through the three dimensional habitat. Some insects are active during the day (diurnal), some during the night (nocturnal) and yet others during dusk (crepuscular). Special eye adaptations are present in all these insects that enable them to have clear vision and perception.

Insect eyes are of two types *viz*., the ocelli or simple eyes and the compound or faceted eyes. Generally ocelli are three in number and occur in the form of a triangle on the head. Compound eyes constitute the main visual aid of the insect and are a pair in number, one on each side of the head. They are constructed from many similar units called ommatidia and functions as a single unit while forming the image.

The eye designs in insects are mainly of two types *viz*., apposition eyes in diurnal insects and superposition eyes in nocturnal insects. In order to have a clear night vision, the superposition eyes are modified. The main modifications are in the optical elements and photoreceptors (Frederiksen, 2008). Optical adaptation parameters include the spatial resolution, temporal resolution, sensitivity inferred from static image and spatial information capacity. Signal transduction and visual noise are the photoreceptor adaptations (Chapman, 2008). Apposition eyes are also modified for vision during night hours in certain insects. The adaptation features in these eyes include the optical parameters *viz*., facet size, dioptric angle, dimensional changes of rhabdom and pigment migration within the retina.

Nocturnal insects have special eye features like large facet lenses and wide and long rhabdom that facilitate colour vision during night hours (Warrant *et al.*, 2004). To navigate back to the nest or to orient them in order to escape from rivals or predators, insects require reliable detection of both celestial and terrestrial cues (Warrant and Dacke, 2011). At night, the brightest and discernable cue is the moon. Terrestrial cues include the pattern of canopy or individual plants and visual landmarks. Bioluminescence is another nocturnal adaptation in which the insects produce and emit light to attract mate and find prey.

The insects due to their compound eyes and mosaic vision are empowered to detect even the smallest objects at its slightest motion, which make them fit for better survival. With their exquisite visual sensitivity, nocturnal insects have evolved the impressive capacity to discriminate colours and navigate at night. However, the real science of colour perception in insects is still to be elucidated further which may help in understanding the success of insect as the most evolved organisms in the animal kingdom.

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Insect: A Marketable Commodity

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Insects have existed on this earth for over 350 million years. Today, insects constitute the largest class not only of the animal kingdom, but also of the whole living world. Besides being identified as crop pests, insects have other valuable properties which make them a marketable commodity. Insects are used for crop pollination and their products are sold as nutritive food for human and livestock. They are used for human health and agricultural protection, also as a tool for conducting research on many aspects of biology.

Insects play a great role in crop pollination. The common pollinators are honey bees, bumble bees, moths, butterflies and beetles. Domestication of bees and bee pollination services have become a common practice in many countries including India as a measure to increase crop production. Many insects are used as agricultural protectants *viz.*, parasitoids, predators and insects that destroy weeds.

Live insects like honey bees and fly maggots are used in the treatment of human ailments. Maggot debridement therapy is one such therapeutic treatment using certain fly larvae (maggots of *Phaenicia sericata*) to remove the dead tissues from wounds and promote healing (Sherman *et al.*, 2000). This medicinal use of maggots is increasing around the world due to its efficacy, safety and simplicity. Coleotherapy is practiced in South American countries (Shi *et al.*, 2005).

Insects have a variety of interesting uses. They are often featured in zoos and living museum displays; sold as pets; bred and released to celebrate special events; ubiquitously adopted for arousing live entertainment. Insects are now getting popular in movies as well as advertisements due to their appealing colour

and charisma.

Insects are an extremely rich source of high-quality proteins, fats, essential vitamins and minerals and so the products derived from them are marketed for their nutritional value (Ramos-Elorduy, 2008). These products form a part of human food, pet food and livestock feed. A number of insects have the ability to secrete substances such as wax, silk and resin through their specialized glands. High value dyes *viz*., cochineal dye can also be extracted from insect tissues. Forensic entomology is an important wing of science where insects and other arthropod identification on or in decaying dead bodies fetches money (Tomberlin *et al.*, 2010).

Commercialization of insects and their products is now moving at a fast pace. Many insect products and by products are now marketed at high commercial value. Apiary, silkworm rearing units, ornament and handicraft making units create a range of possibilities for employment generation and increase the standard of living. In the coming years, insects will become an increasingly valuable product of commerce.

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Can insects be repelled by bad odour? – Mechanism of olfaction in insects

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The sense of smell in insect is stimulated by vapour phase of a great variety of substances which are relatively volatile at ordinary temperatures. Perception of this stimulus is called as olfaction.

Olfactory sensilla or receptors are present on the antennae of all insects, and sometimes on maxillary and labial palps. Olfactory receptor structure is divided into two components, i.e. cuticular components and cellular components.

Cuticular components in the cuticle of olfactory receptors are characterized by the presence of numerous small pores which permit the entry of chemicals. These pores are called as multiporous. Different types of olfactory sensilla are 1. Trichoid sensilla on antennae of *Bombyx mori*, 2. Basiconic sensilla on maxillary palps of female mosquitoes, 3. Coeloconic sensilla on antennae of coleopteran, 4. Placodea sensilla on antennae of honey bee (Chapman, 2006).

Cellular components are the cells of olfactory sensilla which are derived from the epidermis. The number of sensory neurons in olfactory sensilla varies from insect to insect. Two are commonly present in the thick walled pheromone specific sensilla of male moths, but over 20 are present in thin walled receptors of grasshopper.

Olfactory receptors in insects differentiate the odorants which may be semiochemicals i.e. pheromones (sex pheromone, aggregation pheromone, alarm pheromone and trail pheromone) or allelochemicals such as allomones, kairomones, synamones, apneumones, attractants and repellants (Ragumoorthi *et al.*, 2007).

Odorants present in environment when it is contact to cuticle travels through the pores in the cuticle of the olfactory sensilla. Then they diffuse and are carried by an odorant binding protein (OBP) in the lumen of sensillum, as well as bound with OBPs embedded in the dendritic membranes of the olfactory receptor neuron (ORN). Receptor neurons transmit the message into glomeruli of the olfactory bulb.

Olfactory bulbs have numerous glomeruli. Projection neurons connect some olfactory bulbs to mushroom bodies and other parts of protocerebrum. They respond only when the antennal receptors are simulated by a specific odour like a pheromone, attractant or repellent components (Galizia and Rossler, 2010). Others are simply ignored or not recognized.

Insect repellants are the chemicals or substances that induce avoiding (oriented) movement of insects away from their source. There are some examples where insects are repelled by bad odor, as perceived by humans. Repelling mosquitoes by burning neem leaves along with cow dung (Mandavgane *et al.*, 2005) is one such example. To repel honey robber, some stingless social bees erect walls of sticky resin in front or around the nest entrance, while other species smear a repugnant liquid there. But a pleasant smell in eucalyptus oil (p-menthane-3, 8-diols) is known to exert a repellent effect on insects like mosquitoes and fleas (Lett and Kraus, 1994). Osmeterium, an orange, Y-shaped structure on the neck of a caterpillar gives off a strong, unpleasant odour when it is threatened this repel predators and birds and is unpleasant to human.

Odour perception is like visiting a library. There are a number of odorants present in the environment. All groups of insects have specific odours which they receive through specific glomeruli. Hence, there are only odour stimuli in the case of insects. They receive only those known to them. There is nothing like good or bad odour as perceived by humans.

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DEPARTMENT OF AGRICULTURAL EXTENSION

Online Learning Management Systems (LMSs) for Agricultural Education

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Electronic learning or online learning technologies have great potential to spread learning. Much of the success of e-learning can be attributed to the availability of Learning Management Systems (LMSs), also known as Virtual Learning Environments (VLE) or learning platforms. Paulsen (2002) defines an online LMS as: "a software that automates the administration of online learning or training events". All Learning Management Systems manage the log-in of registered users, manage course catalogues, record data from learners, and provide reports to the management.

A robust online LMS should be able to centralize and automate administration; use self-guided services; assemble and deliver learning content rapidly; consolidate training initiatives on a scalable web-based platform; personalize content and enable knowledge reuse (Ellis, 2009). The online LMSs have made huge gains in filling the digital divide (Frausto and Torres, 2010). E-learning must be the future trend for agricultural education and agricultural in-service training (Mohammadi *et al.*, 2011). Blended learning refers to the courses that combine face- to-face classroom instruction with online learning and reduced classroom contact hours (Dziuban *et al.*, 2004).

The important steps in developing an online course includes knowledge about content, system, learners, development of suitable LMS, implementation, evaluation, modification and regular monitoring. Online assessment and certification are also important.

The important models of online learning include supplemental, replacement, emporium, fully online and buffet models. The communication technologies in online learning include both synchronous and asynchronous methods (Awad and Ghaziri, 2008). The online LMSs have their own advantages and disadvantages.

Online LMSs have been successfully used for agricultural education though it has content issues. Globally there are lots of organizations that provide online agricultural courses ranging from certificate courses to doctoral programmes. In India, Tamil Nadu Agricultural University (TNAU) has Agritech Portal that uses online LMS as a component. Institutions like IIT, Chennai and Institute of Management in Government (IMG), Thiruvananthapuram are conducting online courses using LMS.

Majority of the studies on the effectiveness of online learning uphold that blended learning offers more opportunities to address the issues of contextualization and practical work. So the prospects of using online LMS for agricultural education lie in designing courses through a logical blend of online and contact sessions.

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Extension approaches in the changed scenario of Kerala agriculture

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Agricultural extension is a significant social force in agricultural change. Today, the organizations and personnel engaged in agricultural extension undertake a diverse range of activities to adjust to the changing conditions and societal needs. According to Birner (2009), agricultural extension comprises of the entire set of organizations that support and facilitate people engaged in agricultural production and post production activities to solve the problems of their stakeholders and to obtain information, skills and technologies to improve their livelihoods and well-being. Many studies have been made around the world in order to analyse the economic impact of agricultural extension activities. The results revealed an increase in agricultural production and productivity as well as improvement in the knowledge, skills, decision making capacity and conflict resolving power of stakeholders.

Agricultural extension has four popular approaches like technology transfer, advisory service, non formal education and facilitation (Swanson, 2008). Different countries have practiced different predominant models of extension namely, public, private and farmer led extension. In Kerala, public extension is mainly provided by the departments of agriculture, animal husbandry, dairy development, fisheries and forestry. The Agricultural Technology Management Agency (ATMA), defined as a semi-autonomous, decentralized, participatory and market-driven extension model, provides a platform for integrating extension programs across the line departments, linking research and extension units in a district inviting farmers' participation in decision making (Reddy, 2008).

In Kerala, Farm Information Bureau (FIB), Karshaka Information Systems Services and Networking Kerala (KISSAN KERALA), Commodity boards, NGOs and private agencies also provide agricultural extension services. The Kerala Agricultural University, which is the principal instrumentality of the Kerala State in providing human resources, skills and technology to the farmers and other stakeholders has extension activities like On Farm Trials (OFT), Front Line Demonstrations (FLD), Farmer Field Schools(FFS), agro clinics, farm and home focussed trainings, exhibitions and the likewise.

IFPRI (2010) has reported that now a days Public-Private Partnerships (PPP), decentralisation, market-driven extension, use of ICT, Human Resource Development (HRD), Agriclinics and Agribusiness ventures and Farmer Field Schools (FFS) are the recent trends in agricultural extension.

Public extension by the Kerala State Government departments, ICAR institutes as well as the Kerala Agricultural University is not devoid of constraints. Bonny and Mathew (2010) opined that State Agricultural University extension is mostly linear and follows a top-down approach excluding farmer innovations. They projected an innovation facilitation model, namely Farm Transition Network (FTN), which aims at demand driven participatory learning mode of agricultural extension.

To sum up, the economic development of a country is quite difficult without the development of agricultural sector. Agrarian development can be achieved only through worthy research and extension efforts, even though there is no prescriptions for fool proof 'best fit' and 'ideal' approaches. With the advent of changes taking place in the agricultural scenario, vibrant, dynamic and 'end-user worthy' research and extension approaches which are decentralised, stakeholder focussed, need driven and demand driven, have proven to be a strategic necessity.

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Stress Management Strategies in Work Environment

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Stress is an integral and inevitable feature in most workplaces. Even if you work in the most ideal job, you will still encounter stress. Stress is not simply the influence of some negative occurrence, it can be caused by quite ordinary and even positive events. Stress is not entirely a bad event, we all need a certain amount of stimulation in life and most people can thrive on some forms of stress (Stranks, 2009).

Stress has become the most important factor influencing individual efficacy and satisfaction in modern day occupational settings. Once stress exceeds a certain limit, it can cause burnout and detrimentally affect work performance. The teaching profession is increasingly characterized by occupational stress (Mehta and Kaur, 2009). Role overload, role ambiguity, role conflict and dissatisfaction with management were the major reasons for stress at work (Singh and Dubey, 2011).

No single coping practice makes the difference. Rather it is a combination of positive practices that enables us to thrive under chronic pressure. People who exercise regularly are much less likely to suffer from certain types of stresses. Therefore employees may do some kind of exercise such as cycling, jogging and swimming or play softball, tennis etc. Employees may do time management by preparing daily list of activities to be attended to prioritize activities, schedule them and take review daily. A well organised person can achieve twice as much as the person who is poorly organised. Employees should strengthen their social support network so that they will have at least some friends, families or colleagues to turn to, talk to and rely upon. Do yoga or meditation regularly at least for 10-15 minutes. Yoga has the ability to cure several stress related diseases. Listen to

soft music while working. The music will cut off the background noise in the office and will help to feel more focused (Karad, 2010).

Managing stress is not something you do once and forget. Rather it is an ongoing, never ending, sometimes joyful and sometimes frustrating challenge. It will benefit the self by improving quality of life and decreasing risk of illness.

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Human Resource Planning in Agriculture

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Human resource planning is one of the fundamental strategies for the success of any enterprise. It enables an accurate estimate of the number of employees required by matching skill requirements and accomplishment of the organizational goals. Human resource planning is essential in agricultural sector for enhancing optimal use of available resources for increased production in a sustainable manner. It also ensures optimal use of manpower and helps in forecasting the future requirements of human resources in the field of agriculture field. Human resource planning is the process of forecasting, developing and controlling in order to ensure that the right number and kind of people are allocated at the right place and time to make them economically most useful (Mirza, 2007).

India has innumerable potentiality and diverse resources. The foremost and significant resource is the human resource. It has the world's second largest population with varied characteristics such as colour, races, communities, religions etc. Human resources will be either categorized as additive or liability to a country depending upon human resource utilization based on their knowledge, skills, ability and attitudes. Inspite of being bestowed with ample human resources and earnest attempts to develop the knowledge, attitude, skills and abilities of the people, especially in agriculture, the expected success has still not been achieved satisfactorily. This has been due to many shortfalls, constraints and inefficiency in the programme implementations (Pal, 2008)

As a nation, successful efforts have been made in establishing educational institutions and training institutes at various levels to different categories of

people. But the end results and expected outcomes have not registered any direct impact on the target groups.

Kerala state with a literacy rate (93.9%) which is higher than the national average, constitutes one percent of India's total area and represents three percentage of its population (Kumar, 2011). Even though the state is having the highest human development index, unemployment problems are still there due to the fact that the state lacks proper strategies for human resource planning.

Opportunities for rural youth entrepreneurs are several. If educated youth choose to live in villages and launch the new agricultural movement based on the integrated application of science and social wisdom, our untapped demographic dividend will become our greatest strength.

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Hydrogen : The fuel for future

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Owing to an increasing world population and demands for higher standards of living, the future energy demand is expected to increase significantly. Currently, most of the world energy requirement is met by petroleum or natural gas. Unfortunately, the combustion of hydrocarbon fuels contributes to the emission of a large fraction of green house gases and other air pollutants into the atmosphere. In this context, the need of the hour is to develop alternative fuels that satisfy the features of inexhaustibility, cleanliness, convenience, and independence from foreign control.

Among the various alternatives, hydrogen fuel offers the highest potential benefits in terms of diversified supply and reduced emissions of atmospheric pollutants. Hydrogen can be produced from both renewable and non renewable sources. The main renewable sources are electrolysis, biomass conversion, biogeneration, solar energy and wind energy. Non renewable sources include coal, natural gas, gasoline and nuclear power (Pant and Gupta, 2008). At present, natural gas contributes the largest (48%) to world hydrogen production followed by oil (30%), coal (18%) and renewable sources (4%).

CRC (2002) reported that petroleum, natural gas and coal reserves will get exhausted in a matter of 100 to 250 years. So an imperative shift to the use of renewable resources in order to produce hydrogen is needed.

In the advent of hydrogen economy, the principal focus of hydrogen technology was the safe and affordable utilization of hydrogen as an alternative fuel with the integration of generation, distribution, and storage technologies. Hydrogen storage is necessary to patch-up the time-varying energy demands of production output. It can be bulk (large scale) storage, intermediate scale (buffer) storage or small scale

storage near point of use (e.g. on vehicles). Metal hydrides and carbon nanotubes seem promising for small scale storage in vehicles. Onsite generation of hydrogen is a method of delivering the fuel, road and pipeline delivery are others (Bossel and Eliasson, 2003).

Fuel cell technology is revolutionizing hydrogen fuel usage. Vehicles can be powered with hydrogen fuel cells, which are three times more efficient than a gasoline powered engines (Nath and Das, 2004).

Total cost incurred for hydrogen production, distribution and dispensing comes to 7.6 S/kg (if by electrolysis) whereas only 1.12S/kg is incurred for gasoline (NRC, 2004). Even though cost is presently high, the promise of "zero environment pollution" can alone promote the fuel. The impact of the fuel resulted in the establishment of IPHE(International Partnership For Hydrogen Economy) which coordinate multinational research, development and deployment programs that advance the transition to a global hydrogen economy. India is also a member in it.

Hydrogen as a fuel is not an era to start it has already begun. Automobile industry is now concentrating on hydrogen fuel cell operated vehicles. Some examples are Honda FCX, BMW-HR2, Ford-focus-FCV and MAZDA-RX-8-RE.

In the light of reducing green house gas emission as well as dependence on foreign fuels, it is the necessity of every nation to change to a pollution free hydrogen economy.

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e-Governance for Development Administration in Agricultural Sector: Status and Prospects

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Advances in Information and Communication Technologies (ICTs) have made it possible today to provide citizen with a whole range of high-quality and cost-effective services. Electronic Governance (e-Governance) is the application of ICT in the processes of governance. The national and state governments are committed to leveraging these advances for effective development administration, particularly in rural areas (Bhatnagar, 2007).

e-Governance is specifically defined as a process of enabling transaction between concerned group and government through multiple channels by linking all transaction points and repositories of data using ICT to improve the efficiency, transparency and accountability of government (Heeks, 2002). It is widely accepted that e-Governance for development administration can enhance policy formulation promote citizens' participation in government, make planning more effective, improve service quality, empower citizens and enhance citizens' economic and social opportunities. ..

India has been keen on e-Governance initiatives as evident from the National e-Governance Plan (NeGP), though there has been only marginal improvement in this sector. National e-Governance Plan envisions providing all government services in an integrated manner at the doorstep of the citizen, at an affordable cost. The plan consists of various mission mode projects for delivery of "web-enabled anytime, anywhere access" to services through State Wide Area Networks (SWANs), State Data Centers (SDCs) and Common Service Centers (CSCs).

The National Agricultural Policy (NAP) envisions leveraging ICT. e-Governance

in agriculture proposes a scenario which would enhance competitiveness of Indian agricultural produce in world market, improve the efficiency of development departments and streamline dissemination of information to the farming community. e-Governance for agricultural development should essentially consist of Management Information Systems (MIS) for administrative functions like establishment, accounting and resource inventory etc.

However, a critical review of e-Governance programme suggests that many e-Governance projects have not led to any significant improvement in the delivery of government services (Benjamin, 2001). The e-Governance models adopted by various state governments in India are constrained by this problem. But the e-Governance programme in Kerala viz. Information Kerala Mission to support and strengthen democratic decentralization is characterized by participation of stakeholders. This mission developed customized software applications for each component of local body administration with a view to integrate all the developmental functions in a local body. This model lacks mechanisms for networking among various line departments and faces the problems of dual control (Alex, 2009).

There is immense scope for deploying e-Governance in the Department of Agriculture, as the role performance of field level officers in the context of decentralisation can be improved by computerising vital functions such as planning, implementation and monitoring of development programmes, accounting, technical consultancy and advisory services and technology transfer. The e-Governance programme for development administration in agriculture should address the inadequacies of development administration at the grassroots level.

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Avenues for Small Farmer Marketing- Models from Around the World

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Making marketing more efficient is central towards achieving self-employment among the small holder farmers for increased financial success. This is clearly reflected when one is more effective in recognising opportunities unnoticed by others or doing something better in an innovative manner. As such it is essential to create an enabling marketing system that ensures good returns to the farmers at the same time offering reasonable prices to consumers.

For small-scale farmers, knowing where and when to sell their produce is one of the most difficult challenges. Limited knowledge about the current market prices has been the major cause of exploitation. Gathering information about markets may not be easy, especially for people living in very remote areas. However, adequate information is required for farmer decision making processes on quality and specifications of the produce preferred by the markets, volume dealt by each market and comparative price advantages. (The CTA, 2008).

For small scale women farmers, agriculture is often the only source of income. Their economic development is limited by the lack of economic assets, human and social capital (very low level of literacy among smallholders, particularly women). All these factors lead rural women to being very vulnerable to climatic, agronomic and economic shocks (Herbel, 2010).

Marketing channels are routes through which agricultural products move from producers to consumers. In order to exploit the channels, a number of strategies have been developed to facilitate the small farmer marketing across the globe. Marketing therefore, have been conducted by farmers either through selling

produce as individuals or as groups. The models which have been predominant include; lead farmer approach, self-help groups (SHGs), farmer markets, farmer associations, farmer cooperatives, contract farming and e- Marketing.

The lead farmer approach entails a farmer who has been identified by members of a group or community upon whom other farmers rely for marketing information and other innovations. Self Help Group is a small group of people facing similar problems and members help each other to solve their problems. It is useful in assisting members to access loans and develop the spirit of thrift.

Farmer cooperatives are defined as organizations of farmers aimed at improving the marketing environment for poor rural farmers faced with limited and uncertain consumer demand for the goods, help to reduce production costs and act as a medium for capacity building among members (Acharya and Agarwal, 2009).

Contract farming is an arrangement between the farmer-producers and the agri-business firms to produce certain pre-agreed quantity and quality of produce at particular time and price. Farmer markets are designated places where producer-farmers sell their products directly to consumers during the specified time of the year. It is a form of direct marketing which is helpful for increasing small farmers' income. e- Marketing is an online and interactive marketplace that brings buyers and sellers together through the power of internet thus creating a direct marketing forum.

A review of the various marketing mechanisms from across the world shows that marketing channels are by and large contextual and can undergo change according to social and political environment. Total farmer commitment is crucial for their success. No single model can be universally recommended for all situations where small holders are a major force. But farmer- centered models, contract farming and SHGs seem to catch up on a much wider scale because of their inherent advantages. It is clear that bringing the small holder farmer to the mainstream marketing is one thing that needs focus of the development policy makers' world over for a sustainable agriculture.

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DEPARTMENT OF AGRICULTURAL METEOROLOGY

Cloud Seeding

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Weather hazards pose a great threat to the society linked sectors like agriculture, animal husbandry, fisheries, forestry, biodiversity (both land and ocean), water resources and health. In order to minimize the losses due to weather hazards, weather modification strategies can be adopted. There are several methods to modify the existing weather. The most popular method among them is cloud seeding. Cloud seeding is defined as the introduction of a seeding agent into suitable clouds to encourage the formation and growth of ice crystals or raindrops, which in turn enhance the precipitation from the clouds (Denholm, 2010). Cloud seeding provides condensation nuclei for the initiation of collision-coalescence process in warm clouds and ice crystal process in cold clouds (Hess, 1974).

Based on the seeding material used, cloud seeding is classified into glaciogenic and hygroscopic. Glaciogenic seeding is done in cold clouds using ice forming substances like silver iodide and dry ice. Hygroscopic materials like sodium chloride and calcium chloride are used as seeding agents in warm clouds. These materials are released through ground based or airborne systems. There are two types of seeding done by aircraft *viz.*, base seeding and top seeding. For delivering the agents, burn-in-place or ejectable flares are used (Sharma, 2009).

The principle of cloud seeding was discovered by Dr. Vincent J. Schaefer and Dr. Irving Langmuir in 1946 at General Electric Laboratories, New York. Cloud seeding operations in India were started in 1951. At global level, China is the leading country in cloud seeding operations, followed by Russia and Israel. Cloud seeding is also intended for dissipation of fog, hail damage suppression, snowfall augmentation, cyclone modification and lightning suppression (Mahi and Kingra, 2007). However, majority of operational projects are focused on rainfall enhancement. 82 per cent

was the success rate in precipitation enhancement reported from Andhra Pradesh, which is the leading state in cloud seeding operational research.

According to Venkataraman and Krishnan (1992), cloud seeding cannot be done in all types of clouds. Best suited clouds for cloud seeding operations are identified using ground based radar and aircraft systems. Precipitation monitoring is also done by radar, which is supplemented by ground level rain gauge measurements.

The frequency of weather hazards like occurrence of droughts is likely to increase under the projected climate change scenario. Therefore, there is a need to strengthen experiments on cloud seeding as a proactive measure to combat ill effects of drought and to enhance water resources.

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DEPARTMENT OF AGRICULTURAL STATISTICS

Practical View Points in Inferential Statistics

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We compute certain statistics either by our self or with the help of statisticians for drawing inferences based on the data at disposal. The interpretation of the statistics computed will be meaningful only if we are having a sound knowledge of statistical inference. The branch of statistical inference is so vast that, only real time experiences can strike an appropriate impression in one's own mind about the exact interpretations of the statistics computed. The statistics are computed based on the data collected from of course associated on a comprehensive study. The study is conducted with objective/ objectives in mind. The objective in statistical terminology is termed as 'hypothesis'.

Hypothesis testing begins with an assumption, called a hypothesis that we make about a population parameter. Then we collect sample data, produce sample statistics, and use these information to decide how likely is that our hypothesised population parameter is correct (Levin and Rubin, 1998). Hypothesis is a collection of probability distributions. If the collection contains only one, then it is termed as simple hypothesis. If the collection contains more than one it is called as composite hypothesis. The concept of simple and composite hypotheses applies to both null hypothesis and alternative hypothesis.

A procedure by which we may decide either to accept or to reject the hypothesis based on samples taken from the population is called a statistical test. The most frequently recommended test statistics are t, F and Chi- square.

While accepting or rejecting a hypothesis based on a test statistic, we are likely to commit two types of errors (Snedecor and Cochran, 1967).

a. Rejection error (Type I): Rejecting the null hypothesis when it is true is called rejection error.

b. Acceptance error (Type II): Accepting the null hypothesis when it is false is called acceptance error.

á = Probability of type I error
= Probability of rejecting H_1 when H_0 is true

ß = Probability of type II error
= Probability of accepting H_0 when H_1 is false

p -*value*

The ***p*-value** is the probability in the analysis of a test statistic **at** least as extreme as the one that was in fact observed, assuming that the null hypothesis is true or simply ***p* value** is short for probability. The detail that ***p*-values** are based on this assumption is vital to their exact analysis. ***p* value** is the lowest level at which observed value of the test statistic is significant (Das and Giri, 1979). A ***p*-value** can also be reported more formally in terms of a fixed level á test. Here á is a number selected independently of the data, usually 0.05 or 0.01, rarely 0.10. We reject the null hypothesis at level á if the ***p*-value** is smaller than á, otherwise we fail to reject the null hypothesis at level á. The ***p*-value** can be understood in terms of a theoretical replication of the study.

Computational statistics is fast growing as time moves with modern packages at hand. It is easy to speak on exact confidence that we attach to the inferences drawn rather than sticking to levels of confidence like 90 % or 95 %.

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DEPARTMENT OF AGRONOMY

Bioenergy Crops

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India produces only 30 percent of its annual crude oil requirement, which is nearly 105 million tonnes Petroleum consumption increased from 100 million tonnes in 2001-02 to 134 million tonnes in 2008-09. Petroleum resources are finite and therefore searches for alternative sources are continuing all over the world.

Biofuels are alcohols, esters or other chemicals made from cellulose biomass, renewable sources such as fast growing trees, grass, aquatic plants including algae and waste products. Bioenergy crops can be grown for producing ethanol or biodiesel. Ethanol is a product of fermentation while vegetable oils/fats on transesterification are converted into their alkyl esters to produce biodiesel . Ethanol can be extracted from starchy crops such as corn, tubers like cassava and sugar yielding plants like sugarcane, sugarbeet and sweet sorghum (Kumar, 2008). Biodiesel is extracted from oil bearing crops like jatropha and rapeseed, and from aquatic plants including algae. Research is going on in many new sources like switch grass, miscanthus and jerusalem artichoke.

The use of bioenergy offers significant opportunities for reducing green house gas emissions and for increasing energy security. However, an increase in bioenergy production can also put additional pressure on farmland and biodiversity as well as on soil and water resources. Hence, it is important to know how much bioenergy could technically be produced without increasing pressure on the environment (OECD, 1984).

Fuel security is one of the major concerns surrounding the use of biofuels. Biofuel feedstock production competes with food, fibre and timber for land, water and

fertilizers (NRC, 1981). Transformation of biomass bound energy into a usable form of energy such as heat or liquid biofuel is not 100 percent efficient. However, second and third generation biofuels do not threaten food supplies. They hold promise for lower feedstock costs and substantial energy and environmental benefits.

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Carbon Trading

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Climate change is one of the biggest threats humanity is facing today. It has been reported that the mean global surface temperature over the century increased by 0.74°C (IPCC, 2007). The view that human activities are responsible for most of the observed increase in global mean temperature since the mid 20th century is being accepted based on scientific facts (NRC, 2008). Everyday, human activities release substantial amount of green house gases such as methane, carbon dioxide, nitrous oxide and halones to the atmosphere which contributes to global warming and consequently, climate change.

Several approaches are being adopted to reduce carbon emission and to promote activities, which help to store and remove carbon from the environment. These include the commitments of national governments to reduce emission through the 1992 United Nations Framework Convention on Climate Change (UNFCC) and its 1997 Kyoto Protocol. Per-capita emissions in the industrialised countries are typically as much as ten times the average of developing countries. According to the protocol, industrialised countries, which have the main responsibility to mitigate climate change, are listed as Annex I countries and the others as Non–Annex countries. Under Kyoto Protocol, emission caps were set for each Annex-I country, and aims to reduce carbon dioxide level of 5.2 percent from 1990 level (IPCC, 2001).

Kyoto Protocol defines three flexibility mechanisms, International Emissions Trading (IET), Clean Development Mechanism (CDM) and Joint Implementation (JI), which can be used by Annex-I countries in meeting their emission reduction commitments. The efforts made by governments to reduce carbon emission have made carbon a valuable economic commodity. To find a common unit for this

commodity all green house gases (GHGs) are converted to CO_2 equivalents, which are traded in carbon markets. The currency used in these markets is carbon credit, which is equivalent to one tonne of carbon dioxide emissions.

International Emissions Trading allows Annex-I countries to trade their emissions and to meet their emission reduction commitments at a reduced cost. Clean Development Mechanism and Joint Implementation are project-based mechanisms and they generate carbon credits through projects. Most of the CO_2 emission reductions are through renewable energy, energy efficiency and fuel switching projects. In agriculture, forestry and other land use sectors, different types of activities can help to reduce or avoid emission of greenhouse gases (Seeberg-Elverfeldt, 2010).

Carbon trading provides excellent opportunities to reduce carbon emissions, especially that of industrialised countries. It is hoped that viable policies of national governments along with better carbon trading mechanisms will help in achieving the goal of protection of the earth's climate.

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Biotechnology Applications in Weed Management

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Weeds have long been recognized as a major problem causing significant reduction in agricultural production. Several methods are being employed to overcome weed infestation in crop fields. Recent advances in agricultural biotechnology provide us with new options and alternative approaches in dealing with weed problems. The four major areas in the field of weed management technology where opportunities for the application of biotechnology exist are: development and use of bioherbicides, discovery and use of naturally occurring herbicides, genetic improvement of crop tolerance to herbicides and use of genetically engineered microbes for decontamination of herbicide residues.

In the bioherbicide approach, microbial plant pathogens are applied to target weeds. Fungi, bacteria and viruses offer great promise as bioherbicides. Formulations of *Phytophthora palmivora* (De Vine) as a selective mycoherbicide for the control of milk weed (*Morrenia odorata*) in citrus, and *Colletotrichum gloeosporioides* (Collego) for the control of Northern joint vetch in rice and soybean, are now widely used in developed countries. The herbicidal property of *Fusarium pallidoroseum* for the control of noxious aquatic weed *Eichhornia crassipes* was studied by Nazeema *et al.*(1999) and 5% Cashew Nut Shell Liquid (CNSL) solution + 5% Wettable Powder of *Fusarium pallidoroseum* is being recommended for effective control (KAU, 2007). Abraham and Abraham (1999) reported that fungi like *Colletotrichum gloeosporioides, Alternaria alternata* and *Corynespora cassicola* are potential bioagents for the control of alien invasive weed *Mikania micrantha.*

Extensive research has demonstrated that several allelochemicals possess good herbicidal activity. Bialophos, a microbial product from *Streptomyces* sp., exhibits strong herbicidal activity against a wide spectrum of grass and broad leaved

weeds. However, due to their limited selectivity, stable synthetic analogues were developed for commercial use. One such herbicide is the ammonium salt of glufosinate, marketed in India under the trade name Basta (Bayer Crop Science).

Genetic improvement of crop tolerance to herbicides is an area where commercial exploitation of biotechnology has been very successful. The mechanisms of plant tolerance to herbicides vary with the plant and the herbicide. Approaches for development of herbicide resistant crops include classical plant breeding techniques, *in vitro* mutant selection from callus cultures, and transfer of cloned genes to susceptible crops. In the case of glyphosate, whose non-selective broad spectrum activity is due to inhibition of 5-Enol Pyruvyl-Shikimate-3-Phosphate Synthase (EPSPS) in Shikimic acid pathway of amino acid synthesis, tolerance in crops has been achieved by introducing cloned bacterial genes for altering the level/sensitivity of EPSPS. Of the total area under genetically modified crops in the world, 80% is occupied by herbicide tolerant crops such as Roundup Ready (RR) soybean, RR corn, RR canola, RR cotton and RR alfalfa (James, 2004). In the case of soybean and canola, the entire cultivated area is under herbicide tolerant GM varieties.

Apart from this, innovative future applications of genetically engineered microbes include microbial degradation of soil applied herbicides, microbial herbicide safeners and use of microbes as biocatalysts in the production of synthetic herbicides.

Though there are several benefits, emergence of super weeds, genetic contamination of non-GM crops, loss in biodiversity, human health related issues and excessive use of selected herbicides are some of the risks associated with this technology.

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Non-Food Uses of Food Crops

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The range of crops which can be used for non-food purposes is very large but in practice only a small amount of this potential is used on a commercial basis. The principal end products sought for non food use are carbohydrates, fats and fibres (Spelman, 1994).

Rice is the most important cereal crop in India. Several rice varieties have been identified which possess medicinal properties (Nanda and Agrawal, 2004). Njavara is an important medicinal rice in Kerala, used in panchakarma treatment. Rice bran and husk are the major by-products obtained during the processing of grain. Rice bran oil also has some medicinal properties. Rice straw, besides being used for feeding the cattle, can be incorporated in the field itself, which will enhance the productivity (Rathish, 2010).

Coconut, commonly known as 'Kalpavriksha' is highly valued for its non-food uses. Coconut husk is used as a growing medium for orchids, anthuriums etc. Husk burial is an important practice to conserve soil moisture. Coir produced from coconut husk is a major product which is used to make ropes, coir mats, beds etc. Coir geotextiles are widely used for soil conservation in slopy areas which is eco friendly. Coconut shell is used for making different products and the most important product is activated charcoal. Coconut leaf is mainly used for thatching and to make baskets, mats, hats, etc. Coconut oil is the main ingredient in soaps, cosmetics and hair oils. Oil cake is used as cattle feed. Biodiesel can be made from the coconut oil. Coconut trunk is useful for making furniture, boats, handicrafts etc.

Banana, one of the important fruit crops, also has wide uses. Banana plants along with bunches are used for ceremonial purposes. Banana bunches, especially Nendran, were offered as "Kazhchakkula" to the landlords during Onam festival and now these are offered to Lord Guruvayoorappan. Banana fibre is obtained from stem and leaves. Clothes from banana fibre is the national dress of Philippines, called "Barong". Banana starch is used for making glue and fruit juice for making alcohol. Silage can also be prepared from green banana (Stover and Simmonds, 1987).

Cassava is another important food crop having many non-food uses. Cassava starch is used as an adhesive and is having great use in paper and textile industry. Recently, a biopesticide extracted from tapioca leaves is found to be effective to control borer pests (Shanavas, 2010). Cassava hay is produced from young plants after sun drying and biofuel is another product.

Biofuel is the major product from sugarcane which is produced from the bagasse. Other important sugar based products include sucrose esters, sucrose epoxy and bioplastics. Pressmud is used to make compost. Molasses is widely used as an additive and also for alcohol preparation.

Sorghum, bajra and maize are the other important food crops which are used for making biofuel and also used as cattle feed. Starch extracted from maize has also got many uses.

The wider range of crops grown for non-food purposes will allow new opportunities for crop rotation and diversification, and thus potentially enhancing biodiversity. Non-food uses of food crops can also make a positive contribution to environmental protection and conservation. The rapid progress of new technologies such as biotechnology has provided a solution for a wide range of problems in using agricultural raw materials for non-food purposes.

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Sustainable Herbal Farming

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Kerala is considered as the home land of Ayurvedic treatments. Due to uncontrolled deforestation and destructive collection, the biodiversity of medicinal plants in the wild are under threat. The raw materials required for the preparation of Ayurvedic drugs are often adulterated due to the unavailability of quality materials. Domestication and commercialization of medicinal plants is an approach to ensure the supply of quality raw materials.

In India, 70 per cent of the population use traditional medicines. The annual demand of botanical raw drugs in the country was 320 million tons in 2007-08 (Ved and Goraya, 2008). About 90 per cent of the requirement of the medicinal plants are procured from the wild and cultivation accounts only 10 per cent of the supply in active trade. As a result, the demand and supply of medicinal plants are mismatching and this gap can be filled through herbal farming. Herbal farming is the scientific and systematic cultivation of herbs, which include plant materials such as leaves, flowers, fruits, seeds, stems, wood, bark, roots, rhizomes or other plant parts which may be used entire, fragmented or powdered.

Homestead farming is a unique system prevalent in Kerala and the medicinal plants can be easily incorporated in this system. According to Ajithkumar (2009) *Kaempferia galanga, Zingiber officinale, Ocimum sanctum, Adathoda beddomei, Curcuma longa, Curcuma aromatica, Maranta arundinaceae, Coleus aromaticus, Saraca asoca* and *Azadiracta indica* are suitable for homestead farming system . The major factors influencing the yield and quality of medicinal plants are choice of crop and variety, spacing, light intensity, nutrient management, stress, stage of harvest, primary processing and storage. Selection of crops depend on the system of cultivation, market demand, soil charecteristics etc. For example,

closer spacing was found to be better for higher yield and quality in *Curculigo orcheoides* (Joy, 2003). In medicinal plants several factors influence both yield and quality. Combined application of coir pith compost with Azospirillum and phosphorus solubilising bacteria gave higher yield and bacoside content in *Bacopa monnieri* (Latha,2010). The antioxidant content of *Withania somnifera* increased under water stress situation compared to irrigated condition (Jaleel, 2009).

Many farmers consider the cultivation of medicinal plants uneconomical. A major issue is marketing facility. As there is no organised market for the raw drugs or the fresh picks, farmers find it difficult to sell their produce at good price.

Contract farming and value addition are two approaches suggested to get reasonable price for herbal products. Herbal farming can be made sustainable through organised cultivation of medicinal plants, organised marketing, establishing community level small scale processing units and development of quality controlled herbal manufacturing units at community level. Herbal farming is an effective way of conservation of rare and threatened medicinal plants, steady supply of quality raw drugs for Ayurvedic medicines and improvement of lively hood of the rural people

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How Safe are The Herbicides We Use in Kerala?

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Herbicides are the chemicals used to kill the weeds. Out of the total pesticide consumption in India, insecticides are used maximum followed by fungicides and herbicides. But there is a decreasing trend in the consumption of insecticides and fungicides whereas the herbicide consumption is in an increasing trend (NCIPM, 2005). The herbicide consumption of Kerala has also increased from 6 to 10% during 2007- 2010. The commonly used herbicides in Kerala are paraquat, 2, 4- D, glyphosate, oxyflourfen, cyhalofop butyl, diuron, pendimethalin, butachlor, pretilachlor and bispyribac sodium. But the erroneous and continuous use of herbicides can cause problems to crops, residual effects in soil, toxicity to aquatic flora and fauna and finally to the human beings.

When a herbicide is applied to the soil it undergoes different processes like adsorption, chemical decomposition, microbial transformation, formation of soil bound residues and photochemical decomposition. Adsorption is the key factor determining the fate of herbicide in soil, its biological activity and persistence. When a soil is having more than 2% organic matter adsorption occurs and it increases with increase in organic matter. Adsorption of cationic herbicides like paraquat is more in soils with high clay content (TNAU, 1993).

Persistence of herbicides is the residence time of herbicides in soil before being completely removed by physical, chemical or biological degradation. Several factors like soil organic matter, soil microbes, soil texture, soil pH and soil moisture are affecting the persistence of herbicides in soil. Soil organic matter improves the bio efficacy of herbicides in paddy field by increasing adsorption (KAU, 2010). A decreased bacterial population was observed when Butachlor and pretilachlor were applied to the soil (Kannan, 2003). Atrazine and diuron

are the herbicides having the maximum persistence in soil where as paraquat, 2, 4- D and glyphosate are having low persistence (Sankaran *et al.*, 1993).

Potential sources of herbicide pollution in aquatic environment are the herbicides applied in rice, aquatic ecosystem and plantation crops in hilly areas. A herbicide is considered to be a potential pollutant when the solubility of that is greater than 30mg/L. Herbicides coming under phenoxy alkanoics, sulfonyl urea are highly soluble in water. Hydrolysis half life, photolysis half life and field dissipation half life are the factors which indicate ground water contamination potential of herbicides. Herbicide residues were found in fish upto 60 days after spraying when 2, 4- D was applied to control Salvinia (Devi *et al.*, 2006).
The herbicides can enter into the human beings through food chain and cause many health problems like skin and eye irritation, colon cancer, gastro intestinal problems and neurotoxicity. The harmful effects of herbicides can be managed by applying at optimum dose, correct choice of formulation, proper use and cleaning of sprayers; and proper disposal of herbicide containers. An emerging trend is the use of bio herbicides. Many of the living microbes like fungi and bacteria are used to manage the weed problems.

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DEPARTMENT OF HOME SCIENCE

Resistant starch in foods: Nutritional implications

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Starch, the major dietary source of carbohydrates is the most abundant storage polysaccharide in plants. Chemically, starches are homoglycans; composed of a number of monosaccharides or sugar molecules linked together. Amylose and amylopectin are the two main structural components of starch.

The term 'resistant starch' was first coined by Englyst *et al.* (1982). Resistant starch has been defined as the fraction of starch, which resists digestion in the small intestine of healthy individuals and is available for fermentation in the large intestine (Englyst *et al.,* 1992).

Resistant starch (RS) is sub-divided into four fractions: RS_1, RS_2, RS_3, and RS_4 (Fuentes *et al.*, 2010). RS_1 is physically inaccessible to digestion by entrapment in a non-digestible matrix. RS_2 is ungelatinised starch or native starch. RS_3 represents retrograded starch. RS_4 includes selected chemically-modified starches.

Several factors like amylose content, processing which involves heat-moisture treatments, interaction of starch with different components in the food and storage conditions, influence the formation of RS. Technically, it is possible to increase the RS content in starchy foods by modifying the processing conditions such as heating temperature and time, moisture content, repeated heating and cooling cycles and freezing and drying of gelatinised starch.

A number of physiological effects have been ascribed to RS, which have been proved to be beneficial for health. RS acts largely through its large bowel bacterial fermentation products which are short chain fatty acids (SCFA). RS intake seems to decrease postprandial glycemic and insulinemic responses, improve whole

body insulin sensitivity, lower plasma cholesterol and triglyceride concentrations, increase satiety, and reduce fat storage (Higgins, 2004).

Approximately 20g/day of RS is recommended to obtain the beneficial health effects of RS (Sajilata *et al.*, 2006). RS can be determined by *in vitro* and *in vivo* methods.

Resistant starch has desirable physico-chemical properties, making it suitable for incorporating in a variety of foods. A number of commercially available RS preparations would make it possible, for a wide range of applications with nutraceutical implications. RS has received much attention for both its potential health benefits and functional properties.

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Biocatalysts in Food Processing

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Catalysts are substances that modify and increase the rate of a chemical reaction without being consumed in the process. Based on the source, catalysts can be divided into two: chemical catalysts and biological catalysts. Enzymes are the biological catalysts. Pelczer *et al.* (1996) defined enzymes as the biocatalysts, which break down the macromolecule to simpler forms, without undergoing any change by themselves. In 1877, German physiologist Wilhelm Kuhne first used the term enzyme. The name comes from the Greek word *zymosis* meaning 'in leaven' or yeast.

An enzyme molecule has a highly specific binding site or active site to which its substrate binds to produce enzyme-substrate complex. The reaction proceeds at the binding site to produce the products, which remain associated with the enzyme. The product is then liberated and the enzyme molecule is freed in an active state to initiate another round of catalysis. The most important feature of enzyme catalysis is stabilisation of the transition state of the substrates and the reduction of the activation energy of the overall reaction. Enzymes are categorised into six main groups on the basis of the general type of reaction they catalyse.

Enzymes are the unique natural processing aids in the food and beverage industry. There are a number of advantages of using enzymes in food processing. Enzymes are natural nontoxic substances that catalyse a given reaction without causing unwanted side reactions. They are active under mild conditions of temperature and pH, active at low concentrations and the reactions they catalyse can be easily controlled.

Enzymes used in food processing are obtained from three primary sources, i.e., animal tissue plants and microbes. Enzymes are commonly employed for texture modification, increasing yields, recovering high value ingredients, beverage clarification, as bakery aids, for meat tenderisation, milk coagulation and protein hydrolysate preparation (James and Simpson, 1996).

Some commonly used enzymes in food processing are the carbohydrases, proteases, lipases and some oxidizing enzymes. Amongst carbohydrases, alpha and beta –amylases, invertase, cellulase, glucose isomerase and pectinases, are some of the enzymes used in food processing industry. Pectinases for fruit juice clarification under cold conditions is produced using cheap raw pectin rich substrates like orange peel, apple peel and mango peel which are wastes from fruit processing industry (Padma *et al.*, 2011). Proteases are enzymes that cleave a protein molecule by the hydrolysis of peptide bonds. They find important uses in many industries such as baking, meat tenderisation, cheese and beer manufacture. Lipases are enzymes that hydrolyse ester linkages in fats liberating free fatty acids. Lipases are mainly involved in the manufacture of cheese.

Ordinarily, added enzymes are inactivated after they serve the desired purpose, so it cannot be used again. Enzyme immobilisation is a technique to solve this problem. Enzyme immobilisation can be defined as the attachment of enzymes to different types of supports resulting in reduction or loss of mobility of the enzyme (Khan and Alzohairy, 2010).

Enzymes are able to selectively improve flavour, texture, nutritional value and digestibility of foods, because of their efficiency and specificity. The role of enzymes in efficient use of raw materials, improved product recovery and quality may lead to better applications of enzymes in the coming decades.

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Diabetes Mellitus- A Global Threat and its Dietary Management

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Diabetes mellitus or 'madhumeham' has been known for centuries as a disease related to sweetness. World Health Organisation predicts that more than 70 per cent of people in the world live with diabetes in the 21st century. An estimated 285 million people in the world lived with diabetes in 2010 and the number is expected to grow to 438 million by 2030. India has the world's second largest diabetic population (IDF, 2010).

Diabetes mellitus is a chronic metabolic disorder with a strong hereditary basis, associated with high blood sugar and usually with passage of sugar in the urine. Other risk factors include obesity, sedentary life, stress, smoking, ageing and unhealthy eating habits.

The three main types of diabetes are type I diabetes, type II diabetes and gestational diabetes. Type I diabetes affects children with little or no production of insulin. Type II affects overweight or obese adults. The insulin production may be normal or high but is not as effective as normal insulin. Gestational diabetes occur during pregnancy and require insulin injections.

Although, it is not possible to cure diabetes completely, diabetics can lead almost a normal life. Dietary control is central to success in treatment and management of diabetes. The diet should always provide the essentials for good nutrition and adjustments must be made from time to time for changing metabolic needs, growth, pregnancy, or modified activity.

Control of calorie intake to achieve normal weight is a primary objective in the management of all types of diabetes. Both the type and amount of carbohydrate found in food influence postprandial glucose levels and can also affect overall glycemic control in individuals with diabetes (Wheeler and Sunyer, 2008). It is recommended that a diabetic should derive 60 to 65 per cent of calories from carbohydrates, 15 to 20 per cent from proteins and 15 to 25 per cent from fat (Raghuram *et al.*, 2003).

Diets containing high dietary fibre have low calorific value and low glycemic index and therefore diabetics should consume such foods liberally to reduce blood sugar.

Fenugreek seeds appear to have a significant hypoglycemic activity in type II diabetics when they are allowed to drink the extract and chew the seeds of fenugreek due to the presence of fibre and an alkaloid namely trigonelline (Bawadi *et al.*, 2009).

Exercise helps in reduction of body weight and enhances the action of insulin and helps to reduce the dose of drugs. Life style modification through diet and exercise delay the onset of diabetes (Walker *et al.*, 2010).

Diabetes can be kept under control with certain changes in the life style – food intake, exercise and regular intake of prescribed medicines.

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Food security- The Indian Scenario

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Food security exists when "all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996). The problem of food and nutrition insecurity remains as a great threat to large number of poor and vulnerable people across the world. At the global level, the South Asian region is the home to more chronically food insecure people than any other region in the world (MSSRF, 2008).

It has been estimated that in India, one out of four persons goes to bed hungry with a high Global Hunger Index value. In the report published by International Food Policy Research Institute (IFPRI) in October 2010, India was ranked 67 out of 84 countries in the Global Hunger Index based on child malnutrition, child mortality and proportion of people who are calorie deficient (Kumar, 2010).

Food security has three basic components namely availability, access and absorption. Availability of food is a function of food production and access to food is a function of purchasing power and employment. Absorption of food in the body is influenced by nutritional status, education and health care (Swaminathan, 2010).

Though, India is one of the largest producers of the food in the world, nearly 300 million people struggle for meeting two square meals a day and 21 per cent of national population (230 million) are malnourished (Tripathy and Mishra, 2011).

Food insecurity in rural India is primarily a reflection of rural poverty, and thus

overall economic growth and its distributional pattern are important in solving the hunger problem. Those dependent upon low wage income and casual employment do not hope to eat enough throughout the year. Things get worse when drought, climate change and other transitory problems occur. Discrimination by caste and gender are ingrained in society and have a bearing upon livelihood access and food access.

Further, problems of absorption of food into the body occur due to diet imbalances and diseases. Lack of health care facilities, clean drinking water and sanitation worsen the situation which in turn have an impact on life expectancy, maternal mortality, child mortality, infant mortality and malnutrition (MSSRF, 2001).

Food security is in fact the imperative pre requisite for the economic and social stability of the family, community and nation. The deprivation of the basic need represented by food insecurity and hunger are possible precursors to nutritional, health and developmental problems.

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Strategies to combat vitamin A deficiency disorders

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Micronutrient deficiencies have been recognised as one of the major public health problems of developing countries. Vitamin A is the most limiting nutrient in Indian dietaries and hence vitamin A deficiency is wide spread in India. Vitamin A deficiency disorder spectrum has the unique distinction of being one of the most important causes of 'Preventable blindness' the world over.

Vitamin A is an important micronutrient for maintaining normal growth, regulating cellular proliferation and differentiation, controlling development, and maintaining visual and reproductive functions. Vitamin A plays a vital role in the normal functioning of ocular epithelial cells and in the regeneration of visual pigment rhodopsin. Hence deficiency of vitamin A is closely linked with vision. The deleterious consequences of severe vitamin A deficiency disorders (VADD) are night blindness followed by conjunctival xerosis, bitot's spots, corneal xerosis, keratomalacia and total blindness.

Inadequate dietary intake of vitamin A rich foods is the major cause of VADD. Poverty and high cost of vitamin A rich non vegetarian foods, lack of awareness about low cost, nutrient rich food sources, frequent infections like diarrhoea, inadequate breast feeding and faulty weaning practices are the other contributing factors of VADD.

Vitamin A deficiency is estimated to affect approximately 127 million children under the age of five around the world. Approximately 250,000-500,000 children in developing countries become blind each year owing to vitamin A deficiency, half of them dying within 12 months of losing their sight (West, 2002). UNICEF (2004) estimates that around 7 million preschool children in the world were

affected with xerophthalmia. The global prevalence of xerophthalmia was found to be 9.8 million among pregnant women (WHO, 2009).

Periodic vitamin A supplementation is the most widely implemented intervention for controlling vitamin A deficiency in the developing world. Food fortification with vitamin A is already practiced in tackling VADD to benefit poor groups, whose diets are most deficient. ICDS (Integrated Child Development Services) has taken effective steps to impart nutrition education among the rural poor through anganwadi centres. Promotion of household nutrition gardening at rural areas ensures the sufficient availability of low cost β-carotene rich vegetables and it lead to nutrition security of the society.

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Nutrition, Diet and Cancer

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Cancer is one of the most dreaded diseases and is the second most important cause of death in affluent countries. Cancer is the term used to refer malignant neoplasms and tumours. Neoplasia means cells in a tissue proliferate without normal control on growth . Cancer is caused by activation of cellular genes that control the cell growth and cell mitosis (Sreelakshmi, 2000).

The prevalence of cancer in world is estimated as 7.8 million . Cancer of oral cavity is an important contributor to cancer morbidity and mortality in India (Gajalakshmi *et al.*, 2001).

Diet is an important factor of cancer aetiology and cancer prevention. Diet is a complex composite of nutrients and non-nutrient food constituents and many nutrients have relationship with the formation of cancers . Excess calorie intake can lead to obesity and cancer incidence. Higher the body weight , higher is the risk of colorectal cancer, breast, prostate, and ovarian cancers (Sinha *et al.*, 2003). High intake of fat is associated with increased incidence of cancers .

Carcinogen in foods include poly hydroxyl aromatic amines, nitrates and nitrosamines, artificial sweeteners, food additives etc. Some of these are prouduced during cooking, processing, and storage of foods. Unhealthy habits like tobacco chewing, smoking, and alcoholism, which are widely prevalent in India remains a predisposing factors for different types of cancers.

Other constituent in foods like dietary fibre, selenium, beta-carotene, vitamin C, vitamin E etc. have significant protective function against cancer. Isothiocynates present in cruciferous vegetables like broccoli, cauliflower, turnips

etc have been proved to be effective against lung cancer and oesophageal cancers. Lycopene, an important antioxidant, and major colouring pigment in tomato helps to prevent prostate , lung and stomach cancers (Giovannucci, 1999). Phytochemicals present in plant foods act as powerful antioxidants protecting cells and organs from damage caused by free radicals, neutralizing their damaged effects (Polsa, 1998).

The consumption of fruits and vegetables in daily diet contribute various micronutrients, which have many biological effects. The non-nutrient components of these protective foods are also as important as micronutrients. Expected benefits of incorporating a wide variety of fruits and vegetables and whole grains liberally in routine diet may lower the risk of cancer but also reduce the risk of other chronic diseases.

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DEPARTMENT OF OLERICULTURE

Antioxidants in Vegetable Crops

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Vegetables form an integral part of our daily balanced diet ensuring food security as well as nutritional security. They contain significant levels of biologically active components that impart health benefits beyond basic nutrition. Vegetables are considered as protective foods since their consumption prevent the risk of many chronic diseases such as cardiovascular problems, diabetes and certain cancers (FAO, 2004). They are good sources of antioxidants which are essential for the protection of proteins, lipids and DNA, thereby preserving health and vitality.

Antioxidants are substances that are capable of quenching or stabilizing free radicals and play an important role in the body defence system. They are called 'fountains of youth' due to their pronounced anti-ageing effect. Important antioxidants in vegetables are carotenoids, vitamin C, vitamin E, coenzyme Q10, flavonoids, glucosinolates and sulphur containing compounds.

Carotenoids are red, orange or yellow coloured pigments found abundantly in tomato, carrot, spinach and other green leafy vegetables. Nishino *et al.* (2009) reported that use of natural carotenoids suppress liver cancer. They protect the skin from harmful UV radiations. Alpha, beta and gamma forms of carotene and beta-cryptoxanthin have vitamin A activity. Lycopene, the red coloured carotenoid pigment inhibits the oxidation of LDL cholesterol, lowers coronary risk and prevents prostrate and uterine cancers (Rajoria *et al.*, 2010). Xanthophylls (lutein, zeaxanthin, violaxanthin) are commonly present in green leafy vegetables.

Antioxidant vitamins have beneficial effects on cardiovascular and other chronic diseases. Vitamin C prevents the formation of N-nitroso compounds, which are

cancer causing substances. Natural vitamin E is a complex of alpha, beta, gamma and delta tocopherols and tocotrienols. It protects lipid portions of the cellular membranes and prevents atherosclerosis. Coenzyme Q10 is an easily oxidizing lipid soluble molecule which helps to maintain vitamin E in its active form (Kaur and Kapoor, 2001).

Phenolic compounds are important secondary plant products that have beneficial effects on human health by reducing the occurrence of coronary heart diseases and age related eye problems. Quercetin, a potent flavonoid, is mostly found in onion, kale, tomato and lettuce (Singh and Kalloo, 2001). Tomato is rich in melatonin, a hormone with antioxidant property.

Cruciferous vegetables are rich in sulphur containing glucosides called glucosinolates which get hydrolyzed in the presence of myrosinase enzyme to form isothiocyanate, a potent anticancerous compound. Allicin is another sulphur containing compound present in garlic. Oxygen Radical Absorbance Capacity (ORAC) is a viable method for measuring antioxidant capacities in biological samples.

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Physiological disorders in tropical solanaceous vegetables

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In India, solanaceous vegetables play a pivotal role in the total vegetable production scenario. Chilli, tomato and brinjal are the extensively grown tropical solanaceous vegetables which cover the largest area with the highest production. These crops are prone to a number of diseases and physiological disorders, which affect their productivity. Interplay of cultural practices, genetic and environmental factors result in physiological disorders which adversely affect the quality. The major disorders are blossom end rot, cracking, puffiness, sunscald, catface, blotchy ripening, zippering and pox.

The present day consumers, being more quality conscious, insist on quality labels (Guichard *et al.*, 2001). Quality is a combination of visual stimuli and sensory factors and is heavily influenced by product appearance and descriptions. The popularity of tomatoes stems from the fact that they can be eaten fresh or in multiple processed forms. Throughout the world chilli is commercially important as a vegetable, spice, condiment and medicinal crop.

Blossom end rot (BER) is caused by localised calcium deficiency in developing fruits (Peet, 2009). Interactions among daily irradiance, air temperature and humidity, water availability and nutrient ratios contribute to the incidence. It begins as tanned water soaked areas, which later enlarges and becomes black and leathery. Fruit affected by BER ripens prematurely, turning it to an inedible product.

Cracking is the splitting of the epidermis, which may either encircle the stem end or radiate from the stem end to the blossom end. A rapid influx of water and

solutes into the fruit and the reduced elasticity of the fruit skin and pericarp, contributes to the occurrence and severity of cracking. Fruit cracking is a complicated disorder and losses can be very heavy in areas where rainfall is common during ripening. Cracking can be minimised by growing resistant varieties and by adopting cultural practices which result in maintaining consistent soil moisture and reducing diurnal temperature variations (Masarirambi *et al.*, 2009).

Sunscald occurs due to the over exposure of fruits to direct sunlight during hot weather. Dorais *et al.*, (2004) reported that misshapened swollen, catfaced, and hollow fruits could occur due to the low light and non optimal temperature conditions during the floral transition stage. Catface originates in the early stages of flower bud development.

Balanced use of fertilisers to prevent physiological disorders is well understood. But, it is not always harnessed in practice due to the complex interplay of soil, plant and atmospheric influences. Extensive research is required on the question of how to control the physiological disorders and to increase the market value of vegetables. The challenge would be the development of economically feasible systems that reduce physiological disorders, while maintaining adequate yield and quality of tropical solanaceous vegetables.

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Aeroponics : Food From Air

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The world population is expected to reach about nine billion by 2050 from the current level of 6.8 billion. Most of the population growth will happen in urban and semi-urban areas and this population explosion will consume most of the agricultural land for non-agricultural purposes. Soilless cultures like hydroponics and aeroponics may be alternative systems to traditional soil based cultivation and they will scale up the technology of indoor farming. Aeroponics is the process of growing plants, while they are suspended in air, by misting their root system with an atomized nutrient solution. It is designed to optimize plant root access to oxygen and nutrients while minimizing water usage. This process promotes faster plant growth with less water and nutrients than traditional soil-based cultivation.

The basic principle of aeroponic growing is to allow plants to grow under pest and disease free conditions where the aeroponic environment mimics environmental conditions in nature. These conditions encourage healthy plant growth, flowering and fruiting for any given plant species and cultivar. Aeroponic systems are favoured over other methods of water culture like hydroponics and nutrient film technology because the increased aeration delivers more oxygen to plant roots stimulating growth and preventing pathogen formation (Gladon *et al.*, 2006).

Aeroponic growing is considered to be eco-friendly for producing healthy crop plants (Marleen *et al.*, 2011). The main ecological advantage of aeroponics is the conservation of water and nutrients. The system requires only minimum land and labour for proper functioning. These advantages combined with the

results of some research that prove the viability of aeroponics, make aeroponics a logical choice for efficient food production.

The major components of an aeroponic system are air, light, nutrient solution, nutrient reservoir, supporting frames, root chambers and atomizer.

Aeroponics is used for the production of various horticultural crops like vegetables, fruits, flowers, spices and medicinal plants (Albaho and Al-Mazidi, 2005).

It has got other applications like vertical farming, arbuscular mycorrhizal fungi production, space station agriculture, etc. Another major application is as a research tool.

Thus, aeroponics is an improved artificial life support for commercially viable plants. It supports environmental control and rapid unrestricted growth compared to other improved techniques that have been used for decades by traditional agriculturalists. Aeroponic production of crops in controlled environments provides opportunities for improving quality, purity, consistency, bioactivity and biomass production on a commercial scale (Hayden, 2006).

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Prospects of cultivation of underexploited vegetables in Kerala

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Vegetables are the important components among horticultural crops in the diversification of agriculture to provide food and nutritional security for the ever-growing population of the country. India has a wide variety of climate and soils in which more than hundred types of vegetables are grown, but maximum emphasis has been given to a limited number of vegetables only.

Kerala is known for its vast resources of underexploited vegetables which are the store house of nutrients and phyto-chemicals and some are having medicinal uses also. Consumption of these crops has significant health promoting effects. These are considered as protective foods since they can reduce the risk of many chronic diseases such as cardiovascular problems, cancers and various other degenerative diseases (FAO, 2004). Importance of nutritional quality of underexploited vegetables in human health has been reported by Tiwari (2010).

Underexploited cucurbit crops include sweet gourd, ridge gourd, smooth gourd, snap melon etc. High content of protein is reported in spine gourd among cucurbits (Bharathi *et al.*, 2009). Crops like chow-chow and pointed gourd have specific adaptability to certain areas. Protein rich underexploited legumes include jack bean, sword bean, winged bean, dolichos bean etc. KAU has released high yielding varieties in some crops namely "Revathy" in winged bean; "Haritham" and "Deepthi" in ridge gourd.

Cruciferous vegetables are rich in sulphur containing glucoside called glucosinolates and sprouting broccoli has the powerful anticancer components ever detected (Bhat, 2007).

Leafy vegetables are rich sources of fibre and minerals. In addition to commonly used leafy vegetables, a great variety of less familiar greens can be grown in Kerala. Most common among them are chekkurmanis, water leaf, water convolvulus, basella etc. Varalakshmi and Rao (2009) reported higher antioxidant capacity in green leafy vegetables.

Underexploited crops have certain features like adaptability to low input agriculture, resistance to pests and diseases, contribute to food and nutritional security and provide environmental services. Attempts should be made to bring underutilized vegetable crops out of shadows into main stream as these crops are efficient in producing edible dry matter, rich in nutrients and can definitely be utilized as alternate sources towards achieving the goals of food and nutritional security.

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Management of groundwater pollution

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Water is a gift of nature. Groundwater is the largest source of fresh water on the planet excluding the polar icecaps and glaciers. At present, nearly one fifth of all the water used in the world is obtained from groundwater resources. Groundwater pollution has become an ever increasing problem all over the world (Mondal, 2005).

Groundwater contamination occurs when some products such as gasoline, oil, road salts and chemicals get into the groundwater making it unsafe and unfit for use. Some of the major sources of contamination are storage tanks, septic systems, hazardous waste sites, landfills, fertilizers, pesticides and other chemicals (Raghunath, 2007).

Contaminated groundwater has serious health effects. Eighty per cent of water borne diseases such as hepatitis, cholera and dysentery are caused by unsafe drinking water. Certain types of cancer may also result from exposure to polluted water. Irrigating crops with polluted groundwater resulted in crop damage and yield reduction (Verma, 2011). Wildlife can also be harmed by contaminated groundwater.

As there are various sources of contamination, some of the basic preventive measures to avoid it are proper disposal of wastes, waterproof storage of household chemicals (paints, medicines, detergents, etc.) and agricultural pollutants. Proper installation of septic systems along with regular cleaning will reduce groundwater contamination.

Best management practices are specifically designed to address agricultural water pollutants, especially nitrate, phosphate and modern plant protection chemicals. These include nutrient management, integrated pest and disease management, conservation tillage, growing cover crops and irrigation practices (Kumar, 2006).

Over extraction and contamination of groundwater by Hindustan Coca-Cola Beverages Private Limited in Plachimada led to many hazardous health effects. Government passed 'Plachimada Coca-Cola relief and compensation claim special tribunal bill' to pay Rs. 260 cores to the Plachimada victims.

Contaminants must be removed from groundwater before it is being used. The removal of pollutants is called remediation. Remediation is required before the concentration of contaminants exceeds predetermined levels.

Identification of problematic areas and regular groundwater quality monitoring in such areas are the key to reduce groundwater contamination. Prevention and awareness are the best ways to lessen groundwater pollution.

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DEPARTMENT OF PLANT BIOTECHNOLOGY

Genome Targeting Using Zinc Finger Nucleases

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The field of biotechnology has left the door open for finding solutions to the monogenic diseases and disorders. One such new technology showing much promise is targeted gene repair/modification that employs recombinant Zinc Finger Nucleases (ZFN). This approach enables researchers to specifically target and induce repair/modification/prevention of expression of the specific gene.

ZFNs are artificial restriction enzymes in which the non-specific cleavage domain (N) of an endonuclease is fused with zinc finger domain of transcription factors. It can create targeted double strand breaks in the DNA. Later, these broken areas can be repaired by cellular repair pathways like non-homologous end joining (NHEJ) and homologous recombination (HR) (Kim *et al.*, 1996). This technology leads to targeted mutagenesis, gene modification and gene knockout.

The engineering of ZFNs involves the exchanging of á helices and â sheets from various DNA binding proteins to manipulate either sequence specificity or DNA affinity. By this method, it is possible to target any gene in the genome. After selecting the required á helices and â sheets, further addition of a nuclease domain for cleavage enables this artificial protein to manipulate specific gene at the chromosome level (Mandell and Barbas, 2006). Many individual zinc fingers with new specificities have been created by using different methods (Joung and Cathoman, 2008).

The effect of these specific molecular scissors has been tested in various organisms, the most significant one being the Human immunodeficiency virus (HIV). It is already known that HIV gains entry into the cell with the help of Chemokine receptor protein (CCR5) present on the cell membrane. If this protein

is absent, such cells were not infected with HIV. Hence by disturbing Chemokine receptor gene, functional deletion of CCR5 receptor can be achieved by targeted mutagenesis using ZFN resulting in immunity to HIV disease (Perez *et al.*, 2008).

ZFN technology has been used to generate modified fish and rat with gene targeted mutation. Injection of plasmid containing ZFN into rat resulted in targeted suppression of two rat genes *IgM* and *Rab38* (Geurts *et al.*, 2009).

It was demonstrated that in tobacco, transgenic construct including â-glucuronidase reporter gene flanked by ZFN target site can be efficiently deleted from a stably transformed tobacco plant by crossing to a second plant that expresses a corresponding ZFN gene (Worden *et al.*, 2010). Site-directed mutagenesis was reported in an endogenous gene of *Arabidopsis* [*ABA-INSENSITIVE4* (*ABAI4*)] using ZFN approach (Osakabea *et al.*, 2010).

ZFN-mediated gene targeting, together with the potential benefits of recombination mechanism, could finally allow biologists to use precise modifications of endogenous sequences. The generation of genetically modified plant and animal with gene targeted deletion or modification is a powerful tool to analyze gene function and study various genetically controlled diseases and disorders. In addition, crops with valuable new traits might soon be created with more precision and reliability than ever before.

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Towards nanoscale genome sequencing

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The entire genetic material of an organism is genome. The ability to read DNA, also known as sequencing, is critical in understanding inheritance, individuality, disease and evolution. The next generation sequencing (NGS) technologies will enable us to sequence genomes faster and more cheaply than today, promises to accelerate our understanding of the genetic material. The potential outcomes of such improvements include the development of personalized medicines, rapid analysis of genotypes and haplotypes, identification of pathogens (e.g. the development of bio-warfare sensors), discovery of cell-lineage patterns, and exploration of microbial genomes for agricultural, environmental and therapeutic goals.

During Sanger sequencing, the sequence of bases is read from DNA fragments of different length, which are generated by a DNA polymerase that breaks off whenever it encounters a terminator nucleotide. Since the terminator is labelled, the sequence can be read based on the different lengths of the fragments. The large-scale sequencing of complex nucleic acid populations with Sanger sequencing requires sub cloning of the nucleic acids into vectors and their amplification in hosts. The initial sequencing of the yeast, Arabidopsis and human genomes and a host of EST sequencing projects were accomplished by consortia of many laboratories and were very labour intensive. Even with optimised protocols, a mega base (Mb) of sequence costs about US$1330, in contrast, Next generation sequencing (NGS) technologies produce huge amounts of DNA sequences at a much lower cost per sequence, from US$4–90 per mega base, depending on the technology (Wall *et al.*, 2009).

Recent advances in Sanger sequencing include the development of alternative

methods to excite fluorescent dyes like pulsed multiline excitation and new strategies for fluorescence detection. Micro fabricated devices that perform Sanger sequencing might reduce the cost of DNA sequencing (per read) already in use. The most recent demonstration of on-chip sequencing does indicate significant reduction in time to separate DNA. Conventional capillary array electrophoresis takes hours, micro electrophoresis takes minutes. Clonal amplification is a key enabling strategy for micro scale genome sequencing, which is used in both pyrosequencing and fluorescent in situ sequencing. Sequencing by hybridization (SBH) uses oligonucleotide probes in a microarray format that exhibit different affinities for a target sequence of DNA. The concept of a US$1000-genome sequencing technology is an idealized and ambitious objective, which aims to develop instruments that allow for the sequencing of DNA relying on cheaper and faster methods than those currently in use, while maintaining their accuracy (Lister *et al.*, 2009). DNA sequencing using an array of nanometer-sized pores (nanopores) offer an exciting option for third-generation sequencing, which will allow faster and cheaper sequencing with minimal sample pre-processing. When a voltage is applied through a nanopore in a conducting fluid, a slight electric current is observed, the strength of which depends on the structure of the nanopore. When a DNA molecule passed through a nanopore, with an applied voltage, the current detected through the nanopore will differ for each base due to their differential effect on the structure of nanopore.

NGS technologies enable the quick, inexpensive and comprehensive analysis of complex nucleic acid populations (Metzker, 2010). All NGS technologies avoid the sub cloning step and directly sequence the DNA. The development of unconventional and exciting approaches to sequence DNA using nanofabrication might provide the revolutionary advances that would allow the sequencing of whole genomes cheaply and quickly; it is probable that the ability to fabricate smaller structures that exploit electronic (e.g. tunneling current) and optical (e.g. zero-mode waveguides) phenomena will be central to new sequencing technologies (Brutigam and Gowik, 2010).

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Telomerase - Resetting The Biological Clock

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The Nobel Prize in Physiology or Medicine, 2009 was awarded to Elizabeth Blackburn, Carol Grieder and Jack Szostak for their pioneering studies on chromosome termini (telomeres), discovery of telomerase (the enzyme that synthesize telomere repeat units) and how this enzyme prevents chromosome degradation. Telomeres are special nucleoprotein structures located at both ends of linear chromosomes. They protect chromosome termini against fusion, degradation and other inappropriate reactions. The telomeric DNA consists of a short repeating sequence in all organisms. In human beings, the sequence is $^{5'}$ TTAGGG $^{3'}$ repeated 80-1800 times depending upon the type and age of cells (Wyatt *et al.*, 2010). This telomeric DNA forms a large t-loop structure by binding with multi-protein complex. Telomeres help in distinguishing normal chromosome ends from broken ends, thus preventing chromosome fusion by Non Homologous End Joining (NHEJ).

In normal somatic cells, telomeres shorten with every cycle of DNA replication. This is by losing a few repeating units due to the degradation of the terminal RNA primer involved in generating the daughter strand from the lagging strand. Shortening of telomeres below a critical length results in chromosome instability and loss of cell viability.

There is a biological clock for detecting the number of divisions the cell undergoes by "counting" the telomeric loss. This is operating at the G1/S phase checkpoint in the cell cycle. At the end of G1 phase (metabolically active stage) whether the cell is ready for division is checked by "counting" the number of repeat units in telomere. Once the telomere shrinks to a certain level, the cells can no longer divide, its metabolism slows down, it ages and finally dies.

This telomere shortening is overcome by the telomerase enzyme in those cells which divide for longer periods such as germline cells. Telomerase is a cellular reverse transcriptase enzyme that contains an integral RNA subunit, *viz*; telomeric RNA (TR) and a.catalytic protein subunit, the telomerase reverse transcriptase (TERT) (Sykorova and Fajkus, 2009).The telomerase RNA contains a short segment, which encodes the cognate telomere repeat and this segment serves as the template for reverse transcription by TERT.

Role of telomere erosion is presently the most favoured hypothesis of cellular ageing (Valdes *et al.*, 2005).In human beings, certain diseases affecting skin cells, bone marrow cells, liver cells etc. are found in families with insufficient telomerase. As these cells have to be continuously renewed by cell division, the deficiency of telomerase may lead to diseases showing features related to age related diseases.The most common examples are dyskeratosis congenita, liver disease, pulmonary fibrosis etc. (Wong and Collins, 2003).

Telomerase is highly active in tumour cells. About 90 per cent of human tumours contain active telomerase. Its activation in cancer cells makes the cells immortal if other growing conditions are suitable. Cancer cells maintain their telomere by the production or activation of the enzyme and thus continuously undergo cell division. So the enzyme telomerase is said to be resetting the biological clock which detects telomere shortening. As the activity of the enzyme increases in cancer cells, the telomere will not be shortened below the critical level and so the clock cannot detect the number of cell divisions occurred in that cell.

At present several studies are going on to find out the activity of telomerase in cancer cells and the development of drugs to suppress the production or inactivation of the enzyme so that the rapid cell division is stopped. In future, we can hope that assessment of telomere length may be used as markers for early detection of tumours.

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Applications of Stem Cell Technology

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Stem cells are biological cells found in all multicellular organisms which can divide through mitosis and are capable of differentiating into diverse specialized cell types because of their self renewal property (Reya *et al*, 2001) and potency. They are unspecialized cells which can give rise to specialized cell types. They are vital to the development, growth, maintenance and repair of our brains, bones, muscles, nerves, blood, skin and other organs.

Embryonic stem cells and adult stem cells are the two types of stem cells. Embryonic stem cells are pluripotent and can give rise to all types of organs whereas adult stem cells have the ability to differentiate into varieties of a particular type of cell determined by the type of tissue in which they are found.

The phrase "stem cell research" can refer to research using adult stem cells, embryonic stem cells obtained from IVF embryos or those derived from clonal embryos. In 2006 researchers made a breakthrough by identifying conditions that would allow some specialized adult cells to be "reprogrammed" genetically to assume a stem cell-like state. These new type of cells are called induced pluripotent stem cells (iPSCs). They are found to facilitate the development of novel interventions (Vergara *et al*, 2010).

Potential applications of stem cell research are to study the diseases and to provide resources for testing new medical treatments. Stem cell treatment is the type of intervention strategy that introduces new cells into damaged tissue in order to treat disease or injury (Gurtner *et al*, 2007). Studies have shown that these treatments can cure brain damage, cancer, spinal cord injury, deafness, blindness, haematopoesis, diabetes, infertility etc (Giarratana *et al*, 2005).

In veterinary field also stem cell treatments can be used as a curative medicine. Treatments are currently available for horses and dogs (Koch and Betts, 2007). In plants stem cells are present at the shoot and root apical meristems and research attempts are going on using Arabdiopsis as the model organism. But a scientific definition for the plant stem cell is yet to be established.

There are several moral and ethical issues on stem cell research, especially on embryonic stem cells. The reason is that it is derived from the fertilized embryo and the value of life gets neglected. But the technology is now concentrating on deriving stem cells from umbilical cord blood. Stem cell banking can help to improve this technology.

Despite all ethical issues, many countries like China, Mexico, and South Korea are going ahead with stem cell therapies. In India also research on the use of stem cells is going on in over 40 institutions. Certain medical institutes like AIIMS, Kovai Medical Centre, CMC, Vellore, Manipal Cancer Centre, Kottayam Medical College, L.V. Prasad Eye Institute etc. are offering treatments using stem cells for patients suffering from heart damage, spinal cord injury, cancer, diabetes, unilateral corneal blindness etc. There are several moral and ethical issues involved in the therapeutic use of stem cells which have to be addressed and resolved, but the fact remains that stem cells can become a new generation medicine in the coming future.

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Prospects and Consequences of Transgenics in Agriculture

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Genetically modified organism (GMO) contains foreign gene introduced through recombinant DNA technology. The gene transferred is the transgene and the plant developed is referred as transgenic.

The global area under transgenic crops has continued to grow during the last decade. As a result of the consistent and substantial benefits offered by transgenic crops, millions of large, small and resource-poor farmers around the world continued to plant significantly more hectares of transgenic crops in 2010. Accumulated hectarage from 1996 to 2010 exceeded 148 million hectares for the first time, signifying that transgenic crops are here to stay (James, 2010).

GM food promises to meet agricultural needs in different ways. GM crops such as Bt cotton can help to eliminate the applications of chemical pesticide. Herbicide tolerant crop reduces the cost of labour and enhance productivity eg. Roundup Ready Soybean. Several transgenic crop plants are in pipeline with resistance to fungal, bacterial and viral diseases. Transgenic papaya is a good example for a perennial crop with stable resistance to viral disease (Fermin *et al.*, 2010). The "golden rice" with an unusually high Vit. A content would be a novel solution for blindness and other disorders due to Vit. A deficiency (Verma *et al.*, 2011). Transgenic flowers for longer vaselife (Tanaka *et al.*, 1998) and molecular pharming for inexpensive production of chemicals and pharmaceuticals using transgenic plant are the other prospects of transgenics in agriculture (Giddings, 2001).

Introduction of transgenic food into the existing food chain generated lot of apprehensions or possible negative consequences. These include allerginicity, toxicity, horizontal gene transfer and antibiotic resistance, consequences of eating of foreign DNA, viral promoters, changed nutrient levels and loss of biodiversity. To regulate these concerns, biosafety of GM crops and product have been viewed seriously and policies/procedures formulated so as to ensure safety during its development and commercialization (DBT, 2011).

Transgenic technology has the potential to usher in a second green revolution but it requires more transparency in regulatory mechanisms that ensure biosafety. Scientific expertise will be required to address the issues related to risks associated with transgenic crops in proper perspective. Public awareness has to be generated regarding the perceived benefits and risk factors in GM crops. The authentic GM crops may not only have better yield, nutritional and pharmaceutical values but would be resistant to pest and diseases (Jamal *et al.*, 2010).

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DEPARTMENT OF
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SSR Markers for Screening Rice Genotypes

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Identification and selection of specific plants with desirable traits from a population forms the basis of all plant breeding programme. Selection typically involves evaluating a breeding population for one or more traits in field and laboratory conditions (Rajesh, 2009). In the both cases the accuracy of desirable plant identification depends on size and composition of population and environmental conditions. Typically through conventional breeding methods development and release of improved rice varieties or hybrids require 5-10 years.

Considering the extent and complexity of breeding program, rice breeders easily appreciate the usefullness of new tools *viz*., MAS that could make this procedure more efficient. Molecular markers technology offers such a possibility by adopting a wide range of novel approach to improve the selection strategies in rice breeding (Korzun, 2009).

A significant advance in the practical utilization of molecular markers began with the development of SSR markers also referred to as microsatellite markers (McCouch *et al*., 1997). Microsatellites are codominant polymorphic and easy to detect. Recently a fairly dense SSR map of rice has been published. Mapping agronomically important genes can provide useful information for plant breeders (Neeraja *et al*., 2007). This is particularly true in the case of traits that are controlled by multiple genes with similar phenotypes.

Microsatellites have wide range of application in rice diversity studies, genetic mapping varietal line identification DNA fingerprinting, genetic purity testing, Presently, the use of SSR markers in rice is mostly for pyramiding resistance genes and MAB (Bertrand *et al*., 2008). More widespread use is expected with

the improvement of methods for marker analysis and identification of candidate genes for economic traits.

One of the reasons that large population sizes are emphasized in traditional plant breeding is that the genetic control of target traits is not known and the assembly of favourable alleles is undertaken on a trial and error basis.

A more targeted allele assembly through SSR marker application implies that fewer populations needed to achieve the desired result.

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GM Technology in rubber

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Achievements in science and technology constitute to divide the wall between poverty and prosperity. Plant breeding aims at improving the genetic constitution of crop plants. Crop improvement through conventional approaches like hybridization depends on the degree of sexual compatibility among the parents involved. The intensity of such cross fertilization barrier limit the new traits that can be added to those that already exist in that species (Padmanaban, 2011). Genetic engineering is a new type of genetic modification. This technology has already made major breakthrough in this endeavour. (Venkatachalam *et al.*, 2007)

Rubber, belonging to the family Euphorbiaceae spread from its centre of origin Brazil to other countries in the humid tropics. It has evolved itself as an important cash crop contributing to the economic stability of these countries. In India Kerala is the major rubber producing state and the crop plays a major role in livelihood security. (Jayasree *et al.*, 2005)

In India, production of natural rubber is short of its consumption. Rubber productivity is highly influenced by global warming and climate change, especially prolonged drought and tapping panel dryness. In this context development of varieties that can be better tolerate the impact of change in climatic conditions such as breaks in monsoon and protracted period of drought.

RRII (Rubber Research Institute India) has successfully developed genetically modified rubber with increased abiotic stress tolerance. The gene MnSOD (Manganese superoxide dismutase) has been introduced into the

rubber plant. SODs catalyze the dismutation of superoxide to dioxygen and hydrogen peroxide to protect the plant from oxidative damage (Han *et al.*, 1984). Overexpression of MnSOD is expected to give rubber plants the capacity to overcome adverse effect of climate change.

The laboratory studies conducted so far are encouraging and the formal communication of approval for the field trails from GEAC (Genetic Engineering Approval Committee) has been received. Approval for conduct of field trails of GM rubber in Maharashtra has been accorded to RRII.

As GM rubber plants incorporate the target gene (MnSOD) from rubber itself and not from other species it is not transgenic in the strict sense. The social and ethical issues surrounding the introduction and cultivation of GM rubber in Kerala has been exhaustively debated. More scientific approach to this issue is the need of the hour.

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Plant Variety Protection: Indian Scenario

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India is a member of World Trade Organisation and so a signatory of Trade Related Intellectual Property Rights (TRIPS). Article 27.3(b) of the TRIPS agreement reads: "*Members shall provide for the protection of plant varieties either by patents or by an effective sui generis system or by any combination thereof*". So it was mandatory for India to provide protection of plant varieties either by patents or by *sui generis* system or by both. The *sui generis* system means self generated system. Like most developing countries, India decided to exclude patents for plant varieties but exercised the *sui generis* option for their effective protection (Plahe, 2011). India enacted "The Protection of Plant Varieties and Farmers' Rights (PPV & FR) Act, 2001" for plant variety protection.

The objective of India's *sui generis* regime embodied in the PPV & FR Act is to "provide for the establishment of an effective system for the protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new plant varieties" (GOI, 2001). PPV & FRA is a unique legislation that merges breeders' rights, researchers' rights and farmers' rights over plant varieties.

Plant variety protection provides legal protection to a breeder over his variety in the form of Plant Breeders' Rights (PBRs). These are exclusive intellectual property rights granted to a breeder over a registered variety to produce, sell, market, distribute, import or export the variety (Lakshmikumaran and Sridharan, 2009). PBRs is for a period of 15 years for both annuals and extant varieties (from the date of the notification) and 18 years for trees and vines. The PPV & FRA allows the registration of new plant varieties that fulfil the conditions of novelty, distinctiveness, uniformity and stability.

India is among the first countries in the world to have passed legislation granting farmers' rights along with breeders' rights (Sahai, 2003). The Act provides the right to the farmers as breeder, cultivator and conservator of germplasm. Farmers can register their own varieties and have the right to save, use, sow, re-sow, exchange, share or sell the seeds of registered varieties. Researchers are given the right for conducting experiments or research using the registered varieties. The authorisation of the breeder is required for the repeated use of registered variety as parental line for commercial production of newly developed variety. The other features of the Act include disclosure requirement, provisions for benefit sharing, issuance of compulsory licence and establishment of National Gene Fund.

The Govt. of India has established PPV & FR Authority, PPV & FR Registry, PPV & FR Appellate Tribunal and PPV & FR Audit and Account for the effective implementation of the Act. The registration of plant varieties was commenced from 21 May 2007 (Kochhar, 2010). A total of 39 crops are presently eligible for registration under the Act. The PPV & FR Act makes it explicit that the plant variety protection will stimulate research and development in the public sector as well as the private sector.

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Role of Apomixis in Crop Improvement

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In most angiosperm species, seed development involves paternal and maternal gametes: one sperm from a pollen grain fertilizes the egg to produce the embryo, while the other fuses with the secondary nucleus to form endosperm. An exception to this mode of reproduction is apomixis, in which the embryo develops without a paternal gamete and hence will be a clone of the mother. Apomixis, therefore has traditionally been attractive to plant breeders as a means of preserving desirable combinations of genes that might be broken up by segregation and recombination in sexual reproduction (Spielman *et al.*, 2003). Apomixis is prevalent in more than 400 taxa and over 40 families of flowering plants. It is more common in Poaceae, Rosaceae and Asteraceae (Carman, 1997). A detailed classification of apomixis was proposed by Stebbins in 1950.

Genetics of apomixis is highly complex and precise information on this aspect is lacking in many apomicts. In most cases it is governed by one or a few genes. Apomictic gene can be introduced into crop plants either by introgressive hybridisation with apomictic species, mutations or by biotechnological tools. Significant efforts have been made to transfer apomixis from wild to cultivated species like wheat, maize and pearl millet. Direct isolation of genes conferring apomictic development will facilitate the transfer of this trait to a large number of crops. However, this is still in experimental stage.

The significance of apomixis is two fold. Apomixis is an attractive trait for the crop improvement workers, because it mediates the formation of genetically uniform populations and perpetuates heterozygosity and hybrid vigor through successive generations (Bicknell and Koltunow, 2004). Farmers can reuse the seeds produced by the apomictic hybrids generation after generation. It helps in

economic hybrid seed production as the maintenance of apomictic hybrid line is easy and there is no need of isolation in seed production programmes. Apomictic hybrids have been developed in many field and forage crops.

Apomixis also provides an easy and inexpensive method for large scale production of homozygous lines. The doubled haploids, homozygous for all the genes, developed from the haploid apomictic embryos are useful in crop improvement programmes of both self pollinated and cross pollinated crops.

The benefits of apomixis will streamline the productivity, make the breeding of crops more rapid and economize the practices in hybrid seed industry. The estimation of frequency of apomixis, its modification by different environmental conditions and its complex mode of inheritance in most cases causes problems in the utilization of apomixis. However, with gradual accumulation of accurate information on various aspects of apomixis, apomictic breeding will become a powerful tool for the exploitation of heterosis (Mandal *et al.*, 1993).

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Combating Stress Through Wide Hybridization

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Stress refers to adverse condition for crop growth and production imposed by either environmental factors or biological factors. It leads to drastic reduction in crop growth and yield. The losses due to stress can be eliminated by either crop management or crop improvement methods. Crop improvement method is the best approach to combat stress since it is easy to apply and eco-friendly.

Genetic variability is essential for any successful crop improvement programme. Wild relatives of crop plants are important reservoirs of genetic variability for economic characteristics such as disease and insect resistance, tolerance for abiotic stresses and improved quality characters (Kalloo, 1992). The desirable genes in the related species and genera of crop plants can be transferred into cultivated species by distant hybridization. Triticale is a classical example of a distant hybrid that combined grain quality of wheat and winter hardiness of rye.

Several incompatibility barriers such as low crossability, increased sterility, and limited recombination between chromosomes of wild and cultivated species affect the transfer of useful genes (Brar and Khush 2002). Techniques like mixed pollination, grafting and pollination, use of indole acetic acid and pollination, embryo culture and use of mutated pollen are suggested to bring about interspecific hybridization (Peter and Pradeepkumar, 2008).

A number of useful genes for resistance to BPH, WBPH, Bacterial blight, blast and tungro virus was transferred from wild species to cultivated rice. Transfer of resistant gene for grassy stunt virus from *Oryza nivara* to cultivated rice was a major breakthrough in stress resistant breeding of rice. A well known example for wide hybridization is the nobilization of sugarcane which combined yield

and sugar content of *Saccharum officinarum* with the hardiness of *Saccharum spontaneum*.

Popular varieties such as IR 36 (tolerant to many biotic and abiotic stresses), CO31 (resistant to drought) and Dhanarasi (resistant to blast) in rice were evolved through wide hybridization. In Kerala Agricultural University, wide hybridization was attempted by Karuppaiyan (2006) to transfer resistance to fruit and shoot borer in okra (*Abelmoschus esculentus*) from *A. tetraphyllus* and *A. tuberculatus*. Anjitha, an okra variety resistant to YVM was developed and released following wide hybridization and mutation.

Advantage in utilizing wild species to transfer traits of interest across genera/ species over advanced tools of crop improvement is that it is hassle-free and eco-friendly. None of the biosafety and food safety, socioeconomic, risk assessment and risk management issues are applicable to such generated material. To summarise, genes from wild species is available to farmers and researchers all over the world.

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DNA Barcoding: A New Perspective in Taxonomy

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Taxonomy, the science of naming and classifying organisms, is the foundation of biology. Identification and documentation of all forms of life on earth and proper nomenclature of species provide the framework for organizing biological information (Kumar and Jain, 2011). Existing morphology-based diagnostic approaches used by traditional taxonomists are often cumbersome and based on ontogeny. Barcoding organizations note that taxonomists have identified only 15 per cent of all living species over the past 250 years (Ebach and Holdrege, 2005).

DNA barcoding is a novel system designed to provide rapid, accurate and automatable species-identification by using short, standardized gene regions as an internal species tag (Hebert and Gregory, 2005). Small region of the mitochondrial *COI* gene is used in animals for such identification (Hebert *et al.*, 2003). However, *COI* sequence is not appropriate in plants because of a much slower rate of Cytochrome c oxidase I gene evolution (Kress *et al.*, 2005). Consortium for the Barcode of Life (CBOL)-Plant working Group has recommended a combination of chloroplast genes *rbcL* and *matK* as the standard two-locus barcode for plants (Ratnasingham and Hebert, 2007).

Just like Universal Product Code (UPC) which uses a unique series of lines for identification and tracking of a given product, DNA barcodes also uses a unique series of lines to identify a given species. These natural barcodes usually consist of 600 to 650 bp DNA sequence in which each nitrogen base is represented by established colours (Adenine=Green, Thymine=Red, Cytosine=Blue and Guanine=Black) (Hollingsworth, 2008).

DNA barcoding is advancing through the Consortium for the Barcode of Life (CBOL), Barcode of Life Database (BOLD), International Barcode of Life Project (iBOL) and Canadian Center for DNA Barcoding (CCDB). Their major barcoding projects are All Birds Barcoding Initiative, Fish Barcode of Life, Mosquitoes Barcoding of Life and Tephritid Barcoding Initiative of CBOL and Mammalian Barcode of Life.

DNA barcoding has emerged and established itself as an important tool for species-identification and phylogenetic studies in taxonomy. Apart from this, it has proved useful in protecting endangered animals, identifying agricultural pests and disease vectors, tracking adulteration in products and thereby sustaining environment.

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DEPARTMENT OF PLANT PATHOLOGY

Secondary Metabolites of Microbials as Potential Source of Agrochemicals

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Use of chemical pesticides has played a key role in the protection of crops from pests and diseases thereby increasing the agricultural productivity. However, overdependence on pesticides and their indiscriminate use over the last four to five decades have led to the development of pesticide resistance and accumulation of pesticide residues in the environment, leading to serious health hazards. Consequently, there has been a great interest in developing alternative strategies for pest control. One such alternative is the use of microbial pesticides employing microorganisms or their by-products.

Microbial pesticides comprise of microorganisms such as fungi, bacteria and viruses as the combat weapon. These organisms produce a mixture of structurally related compounds referred to as secondary metabolites which have no function in their physiological development (Yamaguchi, 1996). The natural products of microbial origin are categorized into insecticides, fungicides, bactericides, herbicides and nematicides.

The major insecticides of microbial origin include avermectins, milbemectins and spinosyns isolated from actinomycetes. Bacteria such as *Bacillus thuringiensis* and *Photorhabdus luminescens* are considered to be potential insecticides. Avermectins are isolated from *Streptomyces avermitilis* with contact and stomach action targeting on g-aminobutryic acid (GABA) receptor in the peripheral nervous system (Turner and Schaeffer, 1990). Milbemectins from *Streptomyces hygroscopicus* subsp. *aureolacrimosus* show a narrow spectrum of activity compared to avermectins. Spinosyns isolated from soil actinomycete *Saccharopolyspora spinosa* cause rapid death of phytophagous insects such as

caterpillars, leaf miners, thrips and beetles. The toxins produced by *Bacillus thuringiensis* (Bt) are effective against a wide range of insects including Lepidoptera, Diptera and Coleoptera. The insecticidal activity of native Bt isolates was determined by bioassay against the dipteran insect *Drosophila melanogaster* (Sivaji, 2010). Among the different toxins produced by Bt, ä-endotoxin has been used for biocontrol purposes. Toxin upon liberation, docks into epithelial cells and causes them to swell and burst leading to the death of the insect.

Fungicides and bactericides from microbes comprise of strobilurins, blasticidin, kasugamycin, and validamycin which are found effective against plant pathogens like *Venturia inaequalis*, *Cercospora arachidicola* and *Phytophthora infestans*. Among these, strobilurins from wild mushroom *Strobilurus tenacellus* are the new generation fungicides effective against both higher as well as lower fungi. **Comparative efficacy of three strobilurin fungicides was studied against downy mildew of pearl millet** and among these, azoxystrobin offered maximum disease protection (Sudisha *et al.*, 2005). Strobilurins are also effective against most leaf spot diseases, powdery mildew and downy mildew of apple, cucurbits and grapevine. Different species of *Pseudomonas* and *Trichoderma* have emerged as potential biocontrol agents for the major diseases of commercial crops. Kameda *et al.* (1987) reported antifungal activity of validamycin against rice sheath blight caused by *Rhizoctonia solani*.

Bialaphos and vulgamycin are the major commercially available bioherbicides isolated from actinomycetes. These showed excellent control of both monocot and dicot weeds with post-emergence application. Fushimi *et al.* (1989) reported effective control of paddy weeds by the application of vulgamycin.

Hence, several beneficial microorganisms have been found to be the active ingredients of a new generation of microbial pesticides or the basis for many natural products of microbial origin. Being environment friendly and less toxic to non-target pests, these microbial pesticides emerge as a potential option for pest management and hence they can be exploited as a skeleton for the synthesis of new strategies.

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Small RNAs: Big Contributors to Plant Innate Immunity

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Small RNAs are non-coding regulatory RNAs with 20-30 nucleotide (nt) sequences. These plentiful RNAs regulate gene expression at different levels by interfering with mRNA translation. The different forms of small RNAs are classified into small interfering RNAs (siRNAs), microRNAs (miRNAs) and Piwi-associated RNAs (piRNAs) (Ghildiyal and Zamore, 2009).

The pathways for biogenesis and function of various small RNA classes involve shared principles and conserved protein families. An enzyme called Dicer cleaves dsRNA into shorted double stranded siRNAs and one siRNA strand then assembles into an effector complex known as RNA-induced silencing complex (RISC). This complex uses siRNA guide to identify mRNAs with a sequence perfectly complementary to siRNA, cleavage and degradation of mRNA. miRNAs are catalysed by the enzymes Drosha and Dicer. One strand of resulting miRNA duplex incorporates into a RISC complex. Depending on the level of complementarity, miRNAs induce mRNA degradation or repress their translation (Vasquez *et al.*, 2010).

Small RNAs play a critical role in regulating the interaction of pathogens with plants. The plant innate immune system comprises the mechanisms that defend the host plant from infection by other organisms in a nonspecific manner. Plants have evolved multiple layers of defense in response to various pathogens. The preliminary interaction between the pathogen and its host is responsible for Pathogen Associated Molecular Pattern (PAMP)-Triggered Immunity (PTI) in plants. Bacteria counteract PTI by secreting effector proteins into plant cells, which lead to suppression of PTI. Host plants, in turn, have evolved resistance

components such as resistance (R) proteins that can recognize effectors and elicit effector-triggered immunity (ETI) (Chisholm *et al.*, 2006).

Zhang *et al.* (2011) reported that the bacterial component, flagellin, induced the expression of a specific microRNA in *Arabidopsis*, which in turn led to down-regulation of the signaling pathways, increasing resistance of the plant to infection. The involvement of small RNAs in the infection of loblolly pine by the endemic rust fungus, *Cronartium quercuum* f. sp. *fusiforme* was also reported (Lu *et al.*, 2007). A study on small RNAs in interactions between plants and viruses also identified a new miRNA specifically induced by turnip mosaic virus (TuMV). Emerging evidence suggests that endogenous small RNA-mediated gene silencing also serves as a regulatory mechanism in plant immune response to insects and nematodes.

Many studies have shown that, many host miRNAs and siRNAs are induced or suppressed by various pathogen challenges. These pathogen-responsive small RNAs induce posttranscriptional gene silencing by guiding mRNA cleavage/ degradation or translational repression. We expect that many more pathogen-responsive small RNAs will be identified using new technologies, such as high-throughput deep sequencing. These will elucidate the molecular mechanisms of plant defense responses and will ultimately lead to the development of effective tools for controlling diseases in the field.

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Engineering Pathogen Resistance in Crop Plants

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Plant diseases are major limitation to crop production world wide. Management of diseases has primarily been achieved through breeding programmes for either qualitative or quantitative resistance or through the use of pesticides. However, the widespread use of monocultured crops with less genetic diversity can result in development of pathogenic strains that overcome plant defenses and indiscriminate use of chemicals will also result in resistance development and are harmful to beneficial microbes.

Genetic engineering has the potential to overcome many of the shortfalls associated with conventional breeding. It also has the potential to increase disease tolerance to a wide range of pathogens with minimal effect on beneficial microflora. There are varied strategies employed in the development of disease resistant transgenics plants. The first approach of pathogen derived reistance (PDR) was primarily aimed at developing transgenics for viral diseases. The use of coat protein mediated resistance to develop transgenics against Tobacco Mosaic Virus was first reported by Powell- Abel *et al.* (1986). Transgenic plants with the expression of movement proteins and replicases also conferred resistance to many viral diseases. The unveiling of post transcriptional gene silencing mechanism in plants, which is a gene regulation through sequence specific degradation of mRNA was also biotechnologically utilized for engineering resistance against viral pathogens (Dasgupta *et al.*, 2003).

Non pathogen derived resistance mechanisms of disease resistance using antimicrobial compounds were later experimented for the development of transgenics. Expression of PR- proteins, antimicrobial peptides and a wealth of secondary metabolites possess direct antimicrobial activities. Wally and Punja

(2010) reported the development of transgenic plants expressing PR- proteins with chitinase, â-1,3- glucanase and peroxidase activities provided resistance to mainly fungal pathogens with chitin and glucan cell wall. The constitutive expression of antimicrobial peptides, defensins and thionins conferred resistance to a variety of fungi in commercially important crops (Jha, *et al.*, 2009). The expression of phytoalexins and polyphenols through gene manipulations are also reported to have increased antimicrobial properties (Fischer and Hain, 1994).Collinge *et al.*(2010) reported the detoxification of virulence factors produced by pathogens as yet another tool in the development of disease resistant transgenics.

The recent approaches of achieving disease resistant transgenic plants is by introgression of R-genes. Genetic modification of signaling pathways of systemic acquired resistance and induced systemic resistance, which provide innate plant immunity is found to be another promising approach in the new generation transgenic research.

Transgenic technology is highly precise and powerful. It is not a panacea, but has the potential to cope with the much-needed 'Gene Revolution' in the face of a burgeoning population and climate change. Hence genetic engineering for disease resistance is undoubtedly a key biotechnological tool, which will help to mitigate the crop losses incurred due to plant diseases.

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Fatty Acid Derived Signals in Plant Defense

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As sessile organisms, plants need to produce a huge arsenal of chemicals both volatile and non volatiles to adapt and respond to numerous environmental challenges. Among these, fatty acid derivatives occupy a prominent position playing important regulatory roles in plant physiology.

The fatty acid derived oxylipins have significant role in the regulation of plant immune system by providing direct as well as indirect protection against pathogens, pests and abiotic stress. The fatty acid derivative, jasmonic acid (JA) and its analogues are considered as suitable candidates for modulating plant defense responses apart from their physiological functions.

Ohta *et al.* (1991) reported an increased activity of lipoxygenase enzymes and lipid hydroperoxide- decomposing activity in rice leaves of incompatible race - 131 upon infection by blast fungus, *Magnaporthe grisea*. Exogenous application of methyl jasmonate to tomato plants induced increased densities of Type VI glandular trichomes on new leaves, contributing to elevated polyphenol oxidase activity and increased repellency or mortality of insect herbivore (Boughton *et al.*, 2005).

Mandal *et al.* (2006) recorded the induction of defence responses against Karnal bunt of wheat by exogenous application of jasmonic acid, which resulted in decrease in infection by the fungus. They also reported induction of structural defense strategies and programmed cell death against the invading pathogen by jasmonic acid application.

The increased oviposition and population density of Western flower thrips

Frankliniella occidentalis on jasmonic acid insensitive CoI -1 mutant than on wild type *Arabidiopsis* plants were reported by Abe *et al.* (2009). Recent research have developed a novel seed treatment incorporating jasmonic acid, which induced long lasting effects of plant defense against an array of serious pests.

Societal concerns about pesticide residues in food and the adverse effect of pesticides on environment are the factors influencing the development of alternative disease control strategies. Since jasmonates are naturally occurring compounds, understanding the mechanisms regulating JA signaling in plants will provide novel insights into how plant health can be improved by environmental friendly practices for disease and pest control and also for sustainable agriculture.

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Plant Trypanosomatids as Phytopathogen

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Trypanosomatids are flagellate protozoans causing diseases such as Kala-azar, Chaga's disease and sleeping sickness in human beings and animals. It was quite accidental that in 1909 a team of workers under Lafont, a doctor in Mauritius, first brought to light flagellate protozoa in the latex of a Euphorb, *Euphorbia pilulifera*. Owing to the unique morphology and cellular organization, these were classified under the family *Trypanosomatidae*, genus *Leptomonas*, assigning them the name *Leptomonas davidi* (Dollet, 1984).

The genus *Phytomonas* was proposed by Donovan (1909) to differentiate between plant and animal trypanosomatids. The genus also has been further grouped according to the location of the protozoa in the plant: floricola (flower trypanosomatids), fruiticola (fruit trypanosomatids), laticicola (latex trypanosomatids) or phloemicola (phloem trypanosomatids) (Vickerman and Dollet, 1992). The genus *Phytomonas* contains promastigote trypanosomatid flagellates which are parasites and their life cycle is completed in two hosts, a plant and an insect. In plants, some *Phytomonas* species live in the phloem sieve tubes of nonlaticiferous plants like coconut palm, oil palm, red ginger and coffee and are definitely pathogenic. They cause phloem necrosis of coffee, hartrot of coconut palm, marchitez sopresiva of oil palm and wilt and decline diseases of red ginger. Others live in the latex containing cells of laticiferous plants and are not considered to be pathogenic except empty root and decline of cassava. Still other trypanosomatid flagellates parasitize and cause damage to the fruits and seeds of several plants (Agrios, 2005).

Phytomonas wilt or Hartrot is a fatal disease of palm (Arecaceae) species including *Cocos nucifera* and is caused by *Phytomonas staheli*. Crop loss due to

Hartrot varied according to the variety or ecotype and geographic area. Laboratory diagnoses revealed the twisted promastigote form of trypanosomatids in the extracts of shoot apex, leaves, stems and inflorescence of diseased palms. No parasites were found in the roots. Although general anatomy of healthy and diseased palms was similar, callose deposition, plugging by P-protein and plastid alterations were observed in sieve elements of diseased palm (da Cunha *et al.*, 2010).The ability of piercing and sucking insects to transmit plant disease is closely linked to feeding mode and target tissue. Trypanosomatid flagellates of plants appear to be transmitted exclusively by Pentatomorpha (*Lygaeioidea, Coreoidea, Pentatomoidea* and *Pyrrhocoroidea*) (Mitchell, 2004).

Attempts to cultivate phloemic trypanosomatids from coconut trees and oil palms were first made by McGhee and McGhee in 1973. Menara and coworkers (1988) were the first to isolate and culture a flagellate from the phloem of coconut palm inflorescence by introducing infected palm tissue fragments into cultures containing feeder layers of *Mamestra brassica* haemocyte cells supplemented with Grace's medium (Keller and Miguens, 2010).

The mechanism by which protozoa cause disease in plants is not yet well studied. Phloem flagellates cause disease by blocking the transport of photosynthates to the roots. Laticifer inhabiting *Phytomonas* have been shown to produce enzymes degrading pectin and cellulose. Fruit-inhabiting phytomonads seem to cause local damage to fruit around the point of introduction, but this may also be due to concurrent infections by fungi and bacteria (Dollet, 2001).

Plant diseases caused by flagellate protozoa can be managed by cultural methods like pathogen free nursery plants, avoiding contaminated soil, use of resistant varieties etc. The spread of disease can be avoided by the control of insect vectors of these flagellates. There are great opportunities in the field of plant trypanosomatids like development of selective media for culturing flagellate protozoa, detailed study on insect host and parasite interaction and to develop new technologies for management of *Phytomonas* diseases.

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Evolution of Plant Pathogens in Agro-Ecosystem

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Agriculture is not very old; humans started domesticating crops about 10,000 years ago only. However, pathogens have challenged farmers since the first crop plants were domesticated. Selection pressure acting on hosts and parasites are coupled because of their interdependence and hence evolutionary changes may occur in an agricultural ecosystem.

Nature of an agro-ecosystem has played a critical role in the emergence and spread of plant pathogens. The agro-ecosystem provides dense and genetically uniform host population that enables easier pathogen transmission between infected host populations and create a conducive environment for emergence of new pathogens. Extensive cultivation of a single previously resistant variety provides an excellent substrate for the rapid development and spread of the new race of the pathogen and it usually leads to an epidemic (Agrios, 2005).

An understanding of the evolutionary processes that leads to the emergence of new plant pathogens is essential to assess the risks posed by the potential future pathogens. Mutation, population size, genetic drift, gene flow and reproduction system are the characters of plant pathogens responsible for evolution (McDonald and Linde, 2002).

Models for the emergence of new pathogens in an agro-ecosystem are pathogen domestication along with host, host shift and host jump, horizontal gene transfer and interspecific hybridization (Stukenbrock and McDonald, 2008).

In case of pathogen domestication along with host, host and pathogen co-evolved and the centre of origin of pathogen is same as the centre of origin of host. In

host shift, pathogen infects a new host which is a close relative of the former host, whereas in host jump, it infects a new host that is taxonomically very distant from the former host. Transfer of barley scald pathogen *Rhynchosporium secalis* from wild barley to domesticated barley is an example of host shift. Evolution of ergot pathogen, *Claviceps* sp. is by interkingdom host jumps from animals (Spatafora *et al.*, 2007).

In horizontal gene transfer, exchange of specific genes or genomic regions occurs between species that are reproductively isolated. Interspecific hybridization involves exchange of entire genome between different species and leads to changes in chromosome number, ploidy level etc. Mathew *et al.* (2000), studied tomato bacterial wilt and reported the variability of *Ralstonia solanacearum* existing in Kerala.

Adoption of environmental, species and genetic heterogeneity within the cropping system, careful use of plant protection chemicals and proper resistance breeding strategies help to overcome plant pathogen evolution in an agro-ecosystem.

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Fungi for Bioremediation of Pesticides

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In modern agriculture enormous amount of pesticides are applied annually to increase the production by controlling the harmful effects of targeted organisms like insects, fungi, bacteria, viruses etc. The major environmental concern of pesticides is their capacity to leach down to subsoil and contaminate the ground water. Excessive and persistent use of pesticides results in deterioration of the environment. So there is a great need to develop safe, convenient and economically feasible method for pesticide remediation.

Pesticides are any substance or mixtures of substances intended for preventing, destroying, repelling or mitigating any pest. They can be subcategorized into herbicides, insecticides, fungicides, viricides and others according to the targeted pest. Commonly employed and proven methods for remediation of pesticides are chemical treatment, volatilization and incineration. Bioremediation is an innovative technology that is frequently being chosen for the clean up of pesticide contaminated sites. Recent research is expanding the capabilities of this technology. Use of microorganisms (fungi or bacteria), either naturally occurring or introduced, to degrade pollutants is called bioremediation (Pointing, 2001). Process of bioremediation enhances the rate of natural microbial degradation of contaminants by supplementing these microorganisms with nutrients, carbon sources or electron donors. This results in the complete mineralization of contaminants into CO_2 and water without build up of intermediates.

At present, bioremediation conducted on a commercial scale predominantly utilizes prokaryotes, with comparatively recent attempts using white rot fungi. Bacteria are very sensitive to fluctuating environmental conditions in soil since their growth requires films of water in soil pores. However, filamentous fungi

offer major advantages over bacteria regarding the diversity of compounds they are able to oxidize. In addition, they are robust organisms that are generally more tolerant to high concentrations of polluting chemicals than bacteria. Filamentous fungi are also more tolerant to environmental stress and can produce copious amounts of extracellular enzymes during hyphal colonization of soil, resulting in enhanced rate of bioremediation. Therefore, white rot fungi potentially represent a powerful tool for soil bioremediation (Magan *et al.*, 2010).

White rot fungi are those fungi capable of lignin degradation. The random nature of the structure of lignin favours its degradation in a non specific manner. Consequently, other compounds that have an aromatic structure such as pesticides are also easily degradable by lignolytic enzymes. Culture of *Phanerochaete chrysosporium,* the most widely studied for its biodegradative capacity can degrade DDT, lindane and atrazine (Nawas *et al.*, 2011). Lindane can be degraded within 45 days by *Pluerotus ostreatus*. Another white rot fungi *Pluerotus pulmonarius* has the capacity to degrade endosulfan 35 days after spawning (Singh, 2008).

Although white rot fungi possess an efficient enzyme system, they are very slow growing species and also require oxygen rich environment for their growth. To overcome the growth related disadvantages of white rot fungi, there is a need to isolate fast growing non white rot fungal strains capable of rapid and complete mineralization of recalcitrant pesticides. The non white rot fungi like *Fusarium poae* and *F. solani* have the capacity to mineralize lindane on 10th day of incubation (Sagar and Singh, 2010). *F. ventricosum* and *Aspergillus* sp. are excellent tools for endosulfan degradation. Lindane can be degraded within five days of incubation by *Conidiobolus* sp.

Persistent organic pollutants are becoming an increasing global concern now-a-days. Bioremediation using fungi has a better future for removal of contaminants from actual site. With the increasing number of successful implementation, bioremediation will be considered as a proven technology rather than innovative technology. Its popularity is further enhanced because it is perceived as being more 'green' than other remediation technologies.

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DEPARTMENT OF PLANT PHYSIOLOGY

The Enigma of Plant Death

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One of the most puzzling events in a living system is its death. Plants and their parts develop continuously from germination to death. Among angiosperms, life span is highly variable. It ranges from desert annuals which live for only one week to red wood tress and bristle cone pines which live for about 3000-4500 years.

The different life strategies of plants can be described by the terms monocarpy or semelparity and polycarpy or iteroparity (Amasino, 2009). Polycarpic species reproduce repeatedly and live long (eg. perennials) while monocarpic species reproduce once and die (eg. annuals). This suicidal death of plants can be explained as a way of increasing the number of progeny surviving to reproductive age and a way of increasing the rate of evolution.

Ageing is one of the most important factor that leads to death. The complete loss of organization and function during the later part of ageing is termed as senescence. Leopold (1961) defined senescence as the deteriorative processes that are the natural causes of death. Morphologically plant senescence can be classified as over-all senescence, top senescence, deciduous senescence and progressive senescence.

Senescence is a two step process consisting of functional senescence and final senescence. During functional senescence, rubisco constituting 50 per cent of the soluble leaf protein and 30 per cent of leaf nitrogen (Feller *et al.*, 2008) is degraded by hydrolytic enzymes and utilized by the developing plant parts *viz.*, reproductive organs. In the second step, i.e. final senescence, there is a general cellular degradation of the whole plant. This involves degradation of chloroplast and other organelles.

Programmed cell death (PCD) is the active process of cell death which occurs during development and in response to environmental cues. If cells are no more needed, they die by activating intracellular death programme, for this reason this process is named as programmed cell death (PCD) (Palavan-Unsal *et al.*, 2005). PCD includes apoptosis, autophagy and non-lysosomal cell death. Apoptosis is not observed in plants while autophagy operates in the developmental processes and plant immune responses that prevent the spread of diseases. Non-lysosomal cell death is involved in the death of cells due to pathogen attack.

Death is the inevitable end of the process of senescence. Plant death is the process of recycling of nutrients and materials among generations. Plants live for the great purpose of sustaining the universe and they die for the same.

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DEPARTMENT OF PLANTATION CROPS
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Organic Pepper

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Organic agriculture is a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles and soil biological activity. Global area under organic farming is 31 mha spread over in 138 countries. Australia has the maximum area of 12 mha (IFOAM, 2010). India ranks 33rd in terms of area, with 3.95 m ha and production of 16,24,339 MT (2009-10). Fifteen categories of organic agricultural products are exported from the country of which, spices constitute 933.5 MT (4%). Among the organic spices, black pepper is produced in largest quantity. Major countries producing organic pepper are India, Indonesia and Srilanka.

The conversion period required for certification of an organic black pepper farm is three years. Mixed planting of improved varieties available is advised for better genetic base. IISR Sakthi, IISR Thevam and Pournami exhibit tolerance to pests and diseases. Planting materials should be collected from organic gardens. Package is available for soil solarisation, use of organic manures, biocontrol agents and PGPR. Studies conducted by Spices Board had shown that organic nutrition improved pepper yield in Karnataka and Kerala. Biological or organic methods are available for controlling major pests and diseases of black pepper (KAU, 2009).

During harvesting and storage care should be taken to avoid contamination from chemicals. ASTA standards of cleanliness have been laid out for organic pepper. In addition to commonly traded black and white pepper, organic pepper products are also available as green pepper, pepper powder, pepper oil etc.

Organic certification is essential for export of organic spices. Spices Board is

the accreditation body for certifying agencies of spices. India is the first country for group certification. For small farmers under 0.1 ha certification is done at minimum cost. Major certified organic pepper producers are Peermade Development Society, Wayanad Social Service Society and Harisons Malayalam Limited, Cochin. Organic pepper gardens of Kerala are located in Idduki and Wayanad districts. Spices Board provides trainings to farmers on organic pepper production and assistance for acquiring organic certification.

High establishment cost, enormous amount of documentation, poor domestic market and inadequate availability of organic inputs are some of the constraints in organic pepper production (Madan, 2009). However, organic pepper has maximum export demand and several NGOs have developed a strong base in organic pepper production and marketing.

Organic farming is important for maintaining soil health, environment protection, biodiversity conservation and for overall quality of human life.

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DEPARTMENT OF POMOLOGY AND FLORICULTURE

Integrated Nutrient Management in Orchids

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Orchids are known for their long lasting beautiful flowers of myriad shapes, sizes and colours, which fetch a very high price in the international market (Rajeevan *et al.*, 2002). During periods of rapid growth, the plant can accept and use larger amounts of fertilizers, but less frequent and more dilute applications are appropriate when growth is slower such as during the winter months. As orchid plants cannot store much quantities of nutrients for future use, a continuous supply of nutrients is necessary (Naik *et al.*, 2010).

Fertilizers for orchids should contain all the necessary nutrients soluble in water. The proportion of one element to another may vary according to the age and growth rate of the plants and growing medium used. Orchids require both major and minor nutrients, a higher level of N for stimulating vegetative growth and a lower level for flowering. Micronutrients help to improve the quality of flowers (Yadav and Bose, 1985).

A combination of NPK is found best for growth and flowering of a large number of species and hybrids suitable for growing under warm humid conditions (Bose and Bhattacharjee, 1972). Several formulae for fertilizer solutions have been recommended by various workers (Yadav and Bose, 1985). Foliar sprays of supernatant liquid of cowdung slurry, inorganic nutrients of $N:P_2O_5:K_2O$ 3:1:1 during vegetative stage, 1:2:2 during flowering period @ 0.2 per cent weekly twice are recommended for orchids (KAU, 2007).

Several organic substances were found to stimulate growth and development in orchids. Fresh as well as dry cowdung, sheep, chicken, pig or fish manure, dried leaves, oil cakes and bone meal are some of the common manures used for

feeding orchid plants (Chua, 1976). Chemical fertilizers are to be properly balanced with organic manures such as cowdung, cow's urine, groundnut cake and neem oil cake. They are to be diluted before application. Since cow's urine contains high levels of salts, a dilution of 1:25 is necessary. For organic manures 1:10 dilution and subsequent storing for 4-5 days before application is ideal.

The use of bio- fertilizers in floriculture is gaining momentum and the earlier work conducted reveal that bio fertilizers could be used as a potential inoculant for orchids. Flower size, spike length and number of flowers per spike were the highest for the application of involving NPK 20:10:10 at 0.2 per cent concentration; twice a week along with the inoculation of *Azospirillum* at planting in *Dendrobium* (Binisha, 2003).

In commercial orchid production, application of NPK fertilizers in combination of micronutrients and organic manures resulted in the higher dry matter production than the application of any one of these alone (Rodrigues *et al.*, 2010).

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Physiology of Growth and Development of Sympodial Orchids

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In orchids, optimisation of the production processes and ensuring a quality product for the market is very important. To achieve this goal, a good basic understanding of orchid physiology is essential. Physiological processes that determine crop yield are photosynthesis, respiration, water relations, mineral nutrition, partitioning of assimilates and storage capacity (Hew and Yong, 2004).

Tropical orchids have either CAM, C_3 or C_4 mode of photosynthesis and these are usually associated with thick leaves and thin leaves . Thick leaved orchids fix CO_2 through the CAM pathway while thin leaved orchids fix CO_2 through the Calvin's cycle. Photosynthesis of orchid leaves is affected by both physiological and environmental factors including leaf age, light, temperature, water stress, sink demand and elevated carbon dioxide (Hew and Yong, 2004).

Flowers of *Oncidium* Goldiana have high PEPC/RUBPC ratio, indicating that it can fix CO_2 primarily through â– carboxylation. Fluctuations in titrable acidity have been observed in flowers of CAM orchid *Dendrobium* (Hew, 1995).

The sympodial orchids have a rhizome which grows horizontally, producing new growths. Well developed sympodial plant contains a clump of shoots of varying age and size (Rajeevan *et al.*, 2006).

In *Dendrobium* protocorms and calli, the respiration rates are higher when grown in a medium with fructose or glucose than those in medium containing sucrose (Hew *et al.*, 1988). In *Cattleya*, root respiration is highest at the root tip

and decreases markedly with increasing distance from the root tip. Net photosynthesis in roots of leafy orchids is masked by high respiration. Marked increase of respiration following pollination is observed in *Cymbidium* flowers (Arditti, 1992). Respiration rates of orchid flowers vary with species. Respiration rate in younger flower is higher than in mature flower in *Oncidium* Goldiana (Hew, 1980).

Growth of roots and leaves of *Cymbidium sinense* is considered to be fastest when the plants are grown with ammonium nitrate as the nitrogen source. Chlorophyll content of leaves is highest in plants grown with ammonium as a source of nitrogen. Moreover, the lowest photosynthetic rate is observed in plants supplied with ammonium nitrate as a nitrogen source (Wen and Hew, 1993).

Sympodial orchids have a highly integrated pattern of assimilate partitioning in which both major sinks (inflorescence and vegetative apex) and minor sinks (leaves, stems and roots) receive ^{14}C assimilates from nearby and distant leaves. The relatively unrestricted assimilate movement between sources and sinks within an orchid suggests the high potential in diverting additional assimilates for inflorescence growth (Hew and Yong, 2004).

Environmental factors play a major role in determining the type of orchids suitable for their growth as well as flowering (Rajeevan *et al.*, 2002). In some species and hybrids of *Dendrobium* and *Cattleya*, the combination of short photoperiod and low temperature induces flowering in the most complete, rapid and uniform manner (Lopez and Runkle, 2005).

Being in the tropics, ASEAN countries are endowed with a climatic condition well-suited for large-scale orchid cultivation. Hence, it is not surprising that considerable efforts have been made to upgrade technology pertaining to commercial orchid cultivation. A good understanding of orchid physiology is the key step to improve orchid cultivation.

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Avenue Planting

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For the healthy and balanced development of a nation, a beautiful environment is just as essential as wealth in the form of material good. Colourful trees and flowers play a great role in making the environment beautiful and refining the minds of inhabitants.

Avenue planting is the method of planting trees on both sides of the road. It combines beauty and utility. Along with aesthetic effect, the functional utilities of trees, like, providing shade, controlling pollution, reducing heat radiation, obstructing glare and providing shelter from wind are also to be taken into consideration. Agro-climatic suitability, height and spread, canopy architecture, growth rate and pollution tolerance are all important characters in selecting trees for avenue planting (Valsalakumari *et al.*, 2008). *Saraca asoka*, *Lagerstroemia speciosa and Pongamia pinnata* are trees with high APTI (Air Pollution Tolerance Index) values which could be potentially used as road side trees (Tripathi *et al.*, 2009).

To get a good looking and well functioning avenue, selection of plant species and design of planting adopted are important. Ornamental dense foliage trees, which provide good shade and flowering trees with pleasing colours are often used for avenue planting. Palms are also used for avenue planting. Formal line planting design with single species is the common method of planting. Species which have synchronised flowering and harmonising flower colour appear more effective when planted side by side. Randhawa (1993) suggested striking colour schemes for avenues with flowering trees.

Selection of planting material and management after planting play crucial roles in the establishment of avenue trees. Tree establishment is quicker in warmer climate and slower in cooler climate. The mechanisms developed for transplanting grown up trees would be useful in urban landscapes where there are chances of destroying avenue trees while widening of city highways (Watson, 2005). For the development of proper canopy form and trunk structure, training and pruning are essential. Pruning is mainly aimed at producing a central main trunk which grows straight up with well spaced laterals.

The towns and villages are made healthier, more beautiful and efficient by well planned streets with avenue planting. We require not only spacious well-planned streets but also well planned roads and parks with planned planting of ornamental trees.

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High Density Orcharding in Tropical Fruits

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With the advances in knowledge about tree architecture, physiology of tree size control, development of dwarfing rootstocks and chemical growth retardants, many growers have adopted closer planting of fruit crops. This system, popularly known as the High Density Orcharding/HDP, enables earlier cropping, high regular yields and improved farm management practices leading to higher productivity and profitability. HDP with some modifications suited to the respective crop could greatly enhance productivity of tropical and sub-tropical fruits.

High density planting is defined as a cropping system in which the highest number of plants are accommodated within a unit area so as to obtain maximum output by optimum utilization of solar radiation, land, water and soil nutrients. It is classified into medium HDP/semi intensive system with 500 to 1500 plants/ha, optimum HDP/ intensive system with 1500 to 10,000 plants/ha and ultra HDP/ super intensive system with 20,000 to 1,00,000 plants/ha (Mohammed and Wilson, 1984).

Strategies for HDP include planting systems, tree training and tree forms, shoot pruning, root pruning, genetically dwarf varieties, dwarfing rootstocks and chemical growth retardants. In case of planting systems, the ground dimensions are optimized for achieving higher planting densities through appropriate orchard designs. Different spacings influence growth, yield and yield characters of papaya (Singh *et al.*, 2010). Training is done to develop plant form that is good in light utilization, small in size, easy to manage and to minimize cutting and branch removal at later stages.

Shoot pruning is the removal of a portion of a tree to shape or maintain tree structure and productivity. Pruning intensities influence fruit weight, volume and total soluble solids in mango (Singh and Sharma, 2010). Root pruning, in general helps to reduce tree size and promotes early fruiting. Genetically dwarf varieties are the most suitable to be used in HDP. Some of the dwarf varieties identified are Neelum, Amrapali, Pusa Nanha, Pusa Dwarf etc. Dwarfing rootstocks are economical, effective and environmentally safe means for controlling tree vigour, tree size and inducing precocity for high density orchards. An aneuploid line of guava (Aneuploid No. 82) is identified as a potential rootstock for Allahabad Safeda (Sharma *et al.*, 1992). Growth retardants are plant growth regulators that retard growth of plants. Multiple applications of small dosages are more effective than a single application of a large dosage.

The potential value of high density planting systems in tropical fruit crops is not fully exploited commercially because of lack of reliable technologies. Among the tropical fruits, HDP is practiced in mango, banana, guava, pineapple and papaya in a limited extent only. However, with judicious blend of our knowledge on the plant growth and development patterns with appropriate available field technologies, it is possible to exploit the benefits of high density planting in tropical fruit crops.

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Dry flowers – a prospective avenue in floriculture

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Flowers have been closely associated with mankind from the dawn of civilization and they have become an integral part of human life. The fresh look and beauty of cut flowers and foliages can be retained for a few days by using some preservatives or chemicals. Here comes the importance of dry flowers and dried plant parts which can be maintained for a few months to years without any damage. Any of the plant parts like flowers, petals, buds, stems, roots, fruits and leaves in a dried form come under the domain of dry flower.

World floriculture industry is fast expanding and becoming a lucrative business in many parts of the globe. It has tremendous potential for export besides domestic consumption. In India, dry flower industry was started in 1975 by Singhvi castle at Kolkata. Currently, it is spread throughout India especially in Tamil Nadu. Total revenue from this industry in India has crossed 400 crores of rupees, out of which Tamil Nadu shares almost 70 per cent. Now, India has become one of the major exporters of dried flower products in the world (Jawaharlal *et al.*, 2010).

Processing of dry flower involves mainly three steps namely drying, bleaching and colouring (Lourduswamy *et al.*, 2001). The most important step is drying and the various techniques used for drying are air drying, embedded drying, press drying, freeze drying and glycerinizing (Bhutani, 1995).

Dehydrated flower and foliage can be used for interiorscaping like wall hanging, ceiling hanging, table arrangement, wall vase, mirror frame, *pot pourri* etc. Dry flowers and their products look fresh and appealing for years together (Jain and Singh, 2010). *Aegle marmelos*, *Bambusa* sp., *Pinus roxburghii*, *Picea smithiana*,

Bougainvillea sp., *Limonium sinuatum*, *Gerbera jamesonii*, *Ixora coccinea*, *Rosa* sp., *Tecoma stans*, *Viola tricolour*, *Zinnia elegens* etc. are the plants usually used for preparing dry flowers.

Dry flower industry is labour intensive and provides employment to many sections of the society. This sector enjoys the benefits of a comparatively low production cost on account of cheap unskilled labour and availability of diverse plant produce in abundance. Dry flower industry in India could flourish by exploiting the nation's rich and varied heritage of biodiversity encompassing a wide spectrum of habitats.

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DEPARTMENT OF PROCESSING TECHNOLOGY

Membrane Process

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Membrane process is an emerging eco-friendly technology. It is a fractionation, purification and macromolecule concentration method. In this process, particles in nano to micron and above ranges are separated from the feed stream, using a suitable membrane. The membrane retains materials with larger size than its pore size and thus separates fungi, bacteria, food contaminants and different food constituents like protein, fat, vitamins, minerals, etc. Membrane can be defined essentially as a barrier, which separates the phases adjacent to it and restricts the transport of various components based on their molecular size (Sinha, 2009).

Membrane process is purely a physical operation and hence there are no chemical changes to the process streams. The separation is a pressure driven technique having little risk of heat damage. Since no phase changes are involved, less energy loss will be there. The size spectrum of materials separated by membrane is enormous. There are two types of membrane process categories based on the direction of flow of feed along the membrane surface *viz.*, dead end filtration and cross flow filtration.

Membrane filtration systems are classified primarily based on their molecular size *i.e.*, they can separate particles that are about 10µm to solute molecules that are a few Angstroms. The important systems involved are reverse osmosis, nanofiltration, ultrafiltration and microfiltration. Reverse osmosis (RO) retains all substances except water. RO finds its application in the production of potable water and concentration of milk and fruit juices. Nanofiltration (NF) also known as 'loose reverse osmosis' and is used when membrane removes materials having molecular weights in the range of 300-1000 Da (Rosenberg, 1995). This filtration technique is applied for the removal of specific components like colouring agents and salts.

Ultrafiltration (UF) separates materials of sizes between 0.001 and 0.01μm (Porter, 1990). It is a selective separation process used to concentrate and purify medium of high molecular weight components such as plant and dairy proteins, carbohydrates and enzymes. UF is typically used to separate whey proteins from whey (Mannapperuma, 1997). Microfiltration (MF) is a sterilization process which removes microorganisms from the feed. It separates particles of sizes between 0.01-10μm. Hence, it finds application in water treatment, dairy industry and fruit and vegetable processing industry as an efficient method for the removal of microorganisms.

Even though there are many advantages for membrane process, there are a few limitations also. It includes the variation in the product flow rate and membrane fouling. This fouling can be prevented by periodic cleaning of the systems.

Membrane technology has made significant advancements in applications contributing to food preservation in the past few decades. It is a powerful method for recovering solvents, concentrating solutions, fractionating different molecular mixtures and maximum retention of flavour and colour in the products. The selection of appropriate membrane and process needs good understanding of the membranes, their cost and effectiveness. Since these technologies have not reached their full potential yet, advanced researches should be carried out for improvement in the design of the existing membrane systems.

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Microwave Processing of Foods

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The industrial and domestic use of microwaves for food processing has increased dramatically over the past few decades. The potential of microwave energy for thermal processing of agricultural commodities was recognised in the 1950's. Due to economic and technical barriers, only in recent decades has domestic and industrial microwave found applications in the processing of different foods including fruits and vegetables (Bargale, 2009). Microwave technology can be used in tempering, thawing, drying, blanching, pasteurisation and sterilisation of foods.

The microwaves are portion of electromagnetic spectrum between far infrared and conventional radio frequency region. Microwaves are produced by microwave generator or magnetron, a type of electron tube within a magnetic field which propagates high frequency radiant energy (Bawa, 2007). Microwave cooking takes place because certain types of molecules are capable of absorbing electromagnetic radiation in the radio frequency range. Microwaves are highly penetrative and the absorption of radio frequency energy within food causes a rapid rise in temperature throughout the material and thus provides a relatively uniform cooking effect (Khader, 2001).

Microwave processing has been successfully applied on a commercial scale to meat cooking, bacon precooking, tempering of meat, poultry, fish, butter, drying of vegetables and pasteurising ready to serve meals. The use of microwave offers a number of advantages over conventional methods of heating like easy start up and shut down process, time saving, lack of heat contact surfaces etc. (Venkateshaiah and Naresh, 2004). Vadivamambal and Jayas (2007) have reported that the quality of microwave treated agricultural products is better

than or equal to that of conventional drying. The container material for use in microwave processing should be strong and rigid, resistant to thermal oven temperature, completely transparent to microwaves and inexpensive.

Food industry in the recent years has witnessed the emergence of microwave oven as a substitute for thermal oven for a number of food manufacturing processes and products. The modern tempo of life as well as the increasing number of working women requires simplified routines and standardisation of foods with lesser preparation time and convenience in usage. The challenge for the food industry lies in the formulation of processed foods that cater to the use of microwaves for cooking or reheating.

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DEPARTMENT OF SOIL SCIENCE AND
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Phytohormones in Soil

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The portion of soil adjacent to the root system of plants which is influenced by the root system is called rhizosphere. It is found that the roots of higher plants exert greater influence on some group of organisms and this is due to the root exudates of these plants. Many microbial interactions were taking place in rhizosphere and the microbes produce secondary metabolites including phytohormones. They are the organic substances that influence physiological processes of plants at very low concentrations. They were produced endogenously by plants and move from the site of production to the site of action. They are the coordinators of plant growth and morphogenesis. There are five major phytohormones like auxins, gibberellins, cytokinin, ethylene and abscisic acid which perform different functions in plants.

In soil, microbial production and root exudation are the main sources of plant growth regulators. Microorganisms produce phytohormones as a secondary metabolite (Rahi *et al.*, 2009). Selvakumar *et al.*, (2010) reported that *Exiguobacterium acetylicum* a cold tolerant bacterial strain from Uttarakhand expressed phosphate solubilization and Indole acetic acid (IAA) production differently at suboptimal growth temperatures. The microbial synthesis is more in the rhizosphere because of the root exudation of precursors. The phytohormonal action of the rhizosphere microflora was found to be efficient when the concentration of tryptophan in rhizosphere was sufficiently high. Aseptic tomato and radish roots were found to exude 4.05 and 340ng tryptophan per seedling per day respectively (Kravchenko *et al.*, 2004).

Soil factors affecting microbial synthesis include substrate and carbon sources, nitrogen, phosphorus, pH, aeration, temperature and trace elements.

Phytohormones influence nodulation, phosphorus solubilization, mineral uptake and nutrient contents in plant produce. Inoculation with effective bacterial strains increased root and shoot growth and nodulation in peas and it is found that the bacterial strain produced IAA which is accounted for overall synergestic effect on growth of peas (Egamberdieva, 2008).

Phytohormones in soil are supplementary to endogenous production and a continuous low level supply will be there which is more effective than single exogenous application. Moreover the studies have to be undertaken for suitable extraction methods, inoculum-precursor interactions and screening of suitable precursors for further improvement of phytohormonal conditions in soil.

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