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Potential Risk of Pesticide Residues in Honey to Consumers

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Introduction

Honey is one of the natural sweeties, as honeybees produced it from the blossom nectar. Honeybees, *Apis mellifera* L. (Hymenoptera: Apidae), perform the essential task of pollinating agricultural crops and native species and are important to produce honey and beeswax. Regarding to its constant use, it may be polluted by pesticide remains. Honey has been used to treat coughs and sore throats, infected leg ulcers, ear aches, measles, eye diseases, and gastric ulcers. Bee products are natural food products; they are rich in minerals, antioxidants, and simple sugars. Honey is known to be rich in both enzymatic and nonenzymatic antioxidants. Honey can also prevent deteriorative oxidation reactions in foods, such as the browning of fruit and vegetables and lipid oxidation in meat, as well as inhibit the growth of food borne pathogens and microorganisms that cause food spoilage. Therefore, in recent years, bee products have received renewed interest as an essential natural resource that can be employed in new therapies free from side effects that are often encountered with the use of synthetic chemical medicines. However, the market competition on these products imposes extra conditions that can only be ensured by complying with quality assurance and certification protocols.

Bee products, including honey, are polluted via different sources of contamination. Environmental contaminants include pesticides, heavy metals, bacteria, and radioactive materials. Pesticide residues have been shown to cause genetic mutations and cellular degradation. In addition to the public health problems, the presence of pesticides in bee products decreases its quality. Basically, the main purposes for monitoring bee products are consumer health protection, international commercial competition, and better product quality. Currently, with growing awareness of consumers over pesticide materials in food and the effect of crop safety practices on the environment, pesticide residues in agricultural crops should not cause a real health threat. Since the beginning of 1950s, organochlorine pesticides were used broadly. Nevertheless, their use was legally forbidden since 1980. These compounds are characterized by stability, deep absorbance on sediments and land, so their residues may still occur in certain foods such as honey. Organophosphorus compounds that have small perseverance and were readily decaying and used broadly nowadays for insect control all over the country as well as synthetic pyrethroid compounds which were used in cotton crop only. (Anonymous,1995). The existence of pesticide remains in honey revealed the necessity of creating control programs to evaluate properly the human exposure to pesticides and the possibility of taking policy decisions to avoid health hazards (Wallner, 1999).

Pesticides and Honey Contamination

Pesticides:

Pesticides are worldwide used in control of bee diseases and pests and in most instant their administration is uncontrolled and applied without approved protocols. Pesticides residues include acaricides, organic acids, insecticides, fungicides, herbicides, and bactericides. Many toxic substances used to control varroatosis and ascospheriosis such as acaricides amitraz, celazole, bromopropylate, coumaphos, flumethrin, and taufluvalinate. The maximum limits of pesticide residues in honey are not included in the Codex Alimentarius. The use of these chemicals inside beehives carries a risk of direct contamination of honey and other hive products. Over 150 different pesticides have been found in colony samples (Mullin *et al.,* 2010).

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The highest residues of pesticides are from varroacides that accumulate in beeswax, pollen, and bee bread and their residue levels increase from honey to pollen to beeswax.

MRLs of many contaminants have been set to levels as small as parts per billion. Different national regulations have established maximum concentrations of pesticide residues permitted in honey, but the lack of homogeneity causes problems in international marketing and trade. The European Union legislation has regulated the MRLs for three amitraz, coumaphos, and cyamizole, which are 0.2, 0.1, and 1 $mg \cdot kg^{-1}$, respectively. The US Environmental Protection Agency has established MRLs for amitraz (1 mg·kg–1), coumaphos (0.1 $mg \cdot kg^{-1}$), and fluvalinate (0.05 $mg \cdot kg^{-1}$). Most studies determine residues of acaricides that are used to control *Varroa jacobsoni*. The most often detected acaricides are bromopropylate, coumaphos, and fluvalinate. Furthermore, the fungicides are other important honey contaminants.

Honey Contamination with Pesticides.

Honey can be contaminated from the environment and from beekeeping practice. It was found that the contamination of honey and other bee products with varroacides is more than ones originating from the environment. Because no MRLs have been established for pesticides in honey, it is hard to evaluate the contamination of honey with pesticides and the extent of possible damage to human health. In India, a study was carried out to explore the extent of pesticide residue in honey produced in the various parts of Himachal Pradesh. It was found that HCH and its isomers were the most frequently detected followed by dichlor-diphenyl-trichlorethylene (DDT) and its isomers. Malathion's residue was found exceeding the MRLs (5 ppb) proposed by the Ministry of Commerce, Government of India. The results showed that honey from natural vegetation contained lesser residues (Choudary and Sharma, 2008). In addition, levels and frequency of organophosphorus and carbamate pesticides were relatively higher in honey samples analyzed in India from 1993–1997.

The majority of honey samples analyzed from Jordan during 1995 contained residues of organochlorine pesticides such as r-HCH, a-HCH, and lindane; with some contaminated with organophosphorus pesticides (Al-Rifai and Akeel, 1997). In Turkey, 24 organochlorine pesticide residues in 109 different honey samples collected were analyzed by gas chromatography electron capture detection. Aldrin, cis-chlordane, trans-chlordane, oxy-chlordane, 2,4(')-DDE, and 4,4(')-DDE were found in all honey samples. (Yavuz *et al*., 2010).

Honey can be contaminated by fungicides used against pests in fruit trees and rape. In Poland, different fungicides which included vinclozolin, iprodione, methyl thiophanate, captan, and difenoconazole were applied in cherry trees; the residue level of these fungicides were recovered from honey and pollen. In Switzerland, honey residues of the fungicides dithianon, pyrifenox, penconazol and cyproconazole which were applied in fruit trees in spring had been detected. In Germany, it was found that carbendazim caused significant residues. Organic contaminants and polychlorinated biphenyl (PCB's), which originate from motor oil, coolants, and lubricants, are still present in the environment and can contaminate bees and their products. The quantities in honey are low while those in wax are high.

Health Impact of Pesticides

- Systemic introduction of pesticides into nectar and pollen may have direct consequences for honey bee health and ultimately lead to pesticide contamination of honey-containing food.
- The effects of pesticides on human health are harmful based on the toxicity of the chemical and the length and magnitude of exposure.
- Aberrantly, farm workers and their families have the greatest exposure to agricultural pesticides.
- Children are most susceptible and sensitive to pesticides due to their small size and underdevelopment.
- The chemicals have the ability to bioaccumulate and biomagnify and can bio concentrate in the body over time.
- Effect of exposure to pesticides ranges from mild skin irritation to birth defects,

tumors, genetic changes, blood and nerve disorders, endocrine disruption, and even coma or death.

- Some pesticides, including Aldrin, chlordane, DDT, dihedron, endrin, heptachlor, hexachlorobenzene, mirex, and toxaphene, are considered persistent organic pollutants (POPs).
- POPs may compromise endocrine, reproductive, and immune systems. Many diseases such as cancer; neurobehavioral disorder infertility, and mutagenic effects might result from chronic exposure. Therefore, some POPs have been banned while others continue to be used.

Conclusion

The potential risk of pesticide residues in honey to consumers is a multifaceted issue that demands careful attention from regulatory bodies, beekeepers, farmers, and consumers alike. While honey is a natural product cherished for its nutritional benefits and taste, the presence of pesticide residues poses a significant concern for human health. Studies have highlighted the widespread occurrence of pesticides in honey samples worldwide, raising alarms about their potential long-term effects on consumer health, including links to various health conditions. Efforts to mitigate these risks must involve comprehensive monitoring programs, stricter regulations on pesticide usage, adoption of integrated pest management strategies by farmers, and support for organic farming practices. Furthermore, consumer awareness and education play a crucial role in promoting informed choices and demanding transparency from honey producers regarding their production methods and pesticide use. Incorporating innovative technologies for pesticide detection and exploring alternative, eco-friendly pest control methods can further contribute to reducing pesticide residues in honey. Ultimately, safeguarding the purity and safety of honey requires collaborative action at every stage of the supply chain, from farm to table. By prioritizing consumer health and environmental sustainability, we can strive towards a future where honey remains a wholesome and untainted delicacy for generations to come.

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2. BIOTECHNOLOGY

Antisense Technology: A Promising Instrument for Agricultural Research

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Introduction

As the global population continues to grow, the need for efficient and sustainable food production is more important than ever. Traditional plant breeding has been beneficial, but the introduction of biotechnology and genetic engineering has transformed the way we improve crops. A key tool in this transformation is Antisense technology, which includes Antisense RNA and RNA interference. This technology allows us to control unwanted organic processes without changing the target gene. It's been crucial in creating crops that yield more, resist diseases and pests, have higher nutritional value, and can tolerate stress. It has also improved crops' resistance to biotic stress, enhanced fruit quality, and increased overall yield.

Decoding Antisense RNA Technology

It is a powerful tool for controlling gene expression. This technique involves the production of a complimentary copy, or antisense RNA, of a specific messenger RNA (mRNA) sequence. When this antisense RNA binds to its target mRNA, it prevents the mRNA from being translated into protein, effectively silencing the gene from which the mRNA was transcribed. This process allows researchers to study the function of specific genes and potentially treat diseases caused by abnormal gene expression. Antisense RNA technology has found applications in various fields, including agriculture and medicine, where it is used for gene knockdown, functional genomics, and therapeutic applications. It represents a significant advancement in our ability to understand and manipulate genetic material for the betterment of human health and agricultural productivity.

Table 1: Tools in Antisense Technology

1.	Antisense Oligonucleotides (ASOs)	These are short pieces of RNA or DNA that are introduced into cells. Antisense oligonucleotides, or ASOs, attach to matching sequences in the RNA of a particular gene, which stops the RNA from being converted into protein.
2.	Natural Antisense Transcripts (NATs)	Numerous genomic locations have transcription units on both strands, leading to the possibility of overlapping transcripts that are oriented in opposite directions. One strand encodes a protein, while the other produces a non-encoding transcript. These non-encoding transcripts, known as NATs, can inhibit the corresponding sense transcript. NATs can be categorized into cis-NATs, transcribed from opposing DNA strands at the same location, and trans-NATs, transcribed from different locations.
3.	Antisense RNA Molecules	When a cloned gene is manipulated to transcribe the reverse DNA strand, it results in the production of antisense RNA molecules. These molecules have sequences that are complementary to the usual RNA transcripts. If these antisense RNA molecules are produced in sufficient quantities, they often bind with the "sense" RNA created by the regular genes, thereby preventing the synthesis of the corresponding protein.
4.	Short Antisense Nucleic Acid Molecules	It involves the synthesis of short antisense nucleic acid molecules using chemical or enzymatic processes. These molecules are then introduced into cells, temporarily inhibiting the production of the corresponding protein.

Table 2: Enzymes in Antisense Technology

1.	Polymerase	This enzyme unwinds the DNA double helix and matches RNA base pairs with the DNA bases to produce the RNA copy of the DNA.
2.	Exonuclease	It is involved in the process of unwinding the DNA double helix.
3.	Ligase	This enzyme works in concert with polymerase and exonuclease to produce the RNA copy of the DNA.
4.	RNase H (non-sequence specific endonuclease)	It is a key enzyme in antisense technology. It identifies and cleaves the RNA strand in an RNA-DNA heteroduplex, leaving the DNA strand intact. When antisense oligonucleotides (ASOs) are introduced into cells, they form RNA-DNA hybrids by binding to their target mRNA through Watson-Crick base pairing. RNase H degrades these hybrids, effectively preventing the translation and expression of the target protein.
5.	Cas9	This enzyme is used in genome editing technology to cut DNA at a specific location. It can be used to cut the DNA of a specific gene, preventing it from being transcribed into RNA and translated into protein.
6.	Ribozyme	Ribozymes, also known as catalytic RNA molecules, are used in antisense technology for their ability to cleave RNA molecules at specific sequences. This property allows them to inhibit the function of specific RNA molecules, thereby regulating gene expression

RNA Interference (RNAi) Technology:

It is a transformative tool in the field of agriculture, enabling precise regulation of gene expression. It operates by selectively silencing specific genes, providing a means to control pests and diseases, introduce new plant characteristics, and boost crop yield. It uses small interfering RNAs (siRNAs) are created from a double-stranded RNA precursor. These siRNAs are then integrated into a multi-protein complex known as the RNA-induced silencing complex (RISC). Once the RISC is equipped with the siRNA, it can bind to the corresponding mRNA sequence, leading to its degradation. This process inhibits the mRNA from being translated into protein, effectively silencing the gene. RNAi has been instrumental in the development of a variety of crops, including nicotine-free tobacco, non-allergenic peanuts, decaffeinated coffee, and nutrient-enriched maize. It has been used to create ultra-low gossypol cottonseed, transforming a previously unsafe byproduct into a valuable source of protein and oil. As such, RNAi technology holds immense promise for revolutionizing agriculture and enhancing crop production.

Table 3: Broad Spectrum of Antisense Technology Applications in Agriculture

1.	Flavr Savr tomato	Antisense RNA used against an enzyme polygalactouronase, a softening enzyme which is responsible for ripening
2.	Transgenic ACMV-resistant Cassava plants	Used against African Cassava Mosaic Virus (ACMV) which causes cassava mosaic disease causing major economic loss in Africa
3.	Formivirsen	It is the first antiviral drug against Cytomegalovirs (CMV)
4.	Transgenic maize	By targeting suppression of LKR/SDH genes with recombinant RNAi (RNA interference), transgenic maize with high free lysine content is produced
5.	Amylose-free transgenic sweet potato plants	The enzyme known as Granule-bound starch synthase I (GBSSI) plays a crucial role in the synthesis of

		amylose, a linear α (1,4) D-glucan polymer, from ADP-glucose. By suppressing the expression of the GBSSI gene in sweet potatoes through RNA interference, transgenic sweet potato plants can be produced that do not contain amylose.
6.	Ultra-low gossypol cottonseed (ULGCS)	RNAi (RNA interference) technology is used for silencing the gene responsible for gossypol production in the seed. The RNAi can be directed specifically to the seeds using a seed-specific α-globulin promoter, ensuring that gossypol levels in other parts of the plant (which serve as a defense mechanism against pests) remained unaffected. Field trials have confirmed the stability and specificity of the ULGCS trait, suggesting that this RNAi-based product has the potential to be commercially viable.
7.	Beta-Carotene enhanced potato	RNA interference (RNAi) technology is used to enhance the beta-carotene content in potatoes. The method involves silencing the beta-carotene hydroxylase gene (bch), which converts beta-carotene to zeaxanthin. Zeaxanthin is another carotenoid, but it does not have vitamin A activity. By inhibiting the conversion of beta-carotene to zeaxanthin, the beta-carotene content in the potatoes is increased.
8.	Male Sterile Rice plants	RNAi technology is adopted to synergistically regulate rice plant height and male fertility to create dwarf male-sterile rice. The RNAi construct pTCK-EGGE, targeting the OsGA20ox2 and OsEAT1 genes, is constructed and used to transform rice via Agrobacterium-mediated transformation.

By manipulating the genetic makeup of plants, we can achieve desirable traits such as altered plant architecture, improved stress tolerance, enhanced nutritional value, and prolonged shelf life. The ability to engineer secondary metabolites and develop seedless fruits or male sterile plants further expands the potential applications of this technology. The use of specific tools and enzymes in antisense technology allows for precise and efficient modifications, leading to significant advancements in agricultural practices.

In conclusion, antisense technology serves as a powerful tool in modern agriculture, enabling us to meet the growing demands for food production, improve crop resilience, and contribute to sustainable farming practices. It holds great promise for the future of agriculture, with the potential to bring about even more revolutionary changes.

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3. ENTOMOLOGY

Unveiling Nutritional Properties and Dietary Benefits of Silkworms

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Introduction

The global population is rapidly increasing and is projected to reach 10 billion by 2050, exacerbating the challenge of food scarcity due to factors like land limitations, climate change, and agricultural pests. This discrepancy between population growth and food production underscores the urgent need for innovative food sources. Insects, recognized as a traditional dietary component for over 2 billion people worldwide, present a promising solution. Among these, silkworms emerge as a noteworthy source of nutrition. They are primarily cultivated for silk production but hold immense potential as a sustainable protein. This article explores the medicinal and nutritional aspects of silkworms in the context of current Sustainable Development Goals, drawing from pharmacology, biochemistry, nutrition, and biomedicine disciplines to elucidate their health benefits and pharmaceutical potential.

Sustainable Development Goals and Silkworm Utilization

The utilization of silkworms aligns with Sustainable Development Goal 2, which aims to eradicate hunger by 2030. Silkworms offer a viable solution, as they can be cultivated with minimal environmental impact, contributing to sustainable agriculture practices. Additionally, the utilization of silkworms promotes a circular economy by utilizing waste products from the silk industry, further reducing environmental degradation and supporting economic development in impoverished regions.

Nutritional Composition and Health Benefits

Silkworm larvae, boast a notable nutritional composition, with 54% protein, 8% fat, 6% fibre, and 6% ash per 100 grams, providing approximately 390 kcal of energy. Pharmaceutical companies harness the anti-diabetic properties of silkworm larvae's complete protein extract, utilizing it as a potential nutraceutical. Silkworm larvae exhibit significant hypoglycemic activity attributed to 1-deoxynojirimycin (DNJ), acquired from mulberry leaves during feeding silkworms offer a rich nutritional profile, with high levels of protein, oils, polyphenols, vitamins, and chitosan. Silkworm eggs are particularly rich in sugars, fats, and vitamin B, while silkworm pupae are abundant in amino acids and harbour nearly 25 different minerals, each playing distinct roles in physiological functions. Phosphorus, magnesium, and calcium are more prevalent with levels varying based on the species and environmental factors. Additionally, silkworm pupae exhibit a low sodium to potassium ratio, potentially reducing the risk of non-communicable diseases like stroke, hypertension, and cardiovascular diseases. Furthermore, silkworm pupae oil contains significant quantities of unsaturated fatty acids, including Omega-3 fatty acids. Experimental studies have revealed numerous health benefits associated with silkworm consumption, including antioxidant, anticancer, antibacterial, hepatoprotective, and immunomodulatory effects.

Silkworm Pupae in Cosmetic and Chemical Industries

With approximately 30% fat content, silkworm pupae are utilized to produce chrysalis oil, a valuable ingredient in cosmetic products such as emulsions, soaps, creams, and lotions. The protein derivative of pupal skin, chitin, and absorbent/resilient hybrid silk films derived from silkworm pupae find applications in scar de-scarring and wound healing. Silkworm pupal fat and oil possess anti-aging properties, darken grey hair, and aid in weight loss, making them beneficial for the soap and cosmetics industries. Silkworm pupal oil is employed in various cosmetic products including body deodorants, face powder, and hair oils. Additionally, silkworm pupae oil finds extensive use in the food processing and oleochemical industries. The waste pupal skin, often available from reeling and grainage industries, serves as a marketable raw material for diverse industries, making silkworm pupae valuable in culinary, cosmetics, pharmaceutical, and chemical sectors.

Silkworm Pupae as Nutritious Animal Feed

Silkworm waste pupae (SWP) serve as a valuable protein supplement for livestock and poultry feed. SWP is processed into affordable dietary supplements for poultry, fish, and carps, improving egg production, egg yolk colour, fish growth rates, and overall profitability. De-oiled pupae enhance egg quality and growth rates in hens, while fat-free pupae are beneficial for fish growth. Diets enriched with silkworm pupae contribute to weight gain and fur growth in rabbits, highlighting their potential as nutritious animal feed.

Safety Evaluation of Silkworm-based Food and Medicine

Silkworms are considered safer for consumption compared to other high-protein foods like shrimp and fish due to their low toxicity and allergenicity. Safety evaluations, including toxicity tests on rats fed with transgenic silkworms, have shown no negative reactions, indicating their safety for consumption. Acute and subacute toxicological investigations on silkworm pupae protein also revealed no fatalities or abnormalities, confirming their safety within recommended consumption levels. However, allergenicity remains a concern, with common allergens identified in silkworm pupae including glycoproteins and chitinase precursors. Techniques such as controlling production conditions and food processing methods like hydrolysis and fermentation can help mitigate allergenicity. Overall, while allergic reactions are possible, various methods can be employed to reduce or eliminate allergens, making silkworms

generally safe for consumption as food or medicine.

Laws and Regulations Concerning Silkworms as Edible Insects

Efforts from lawmakers, regulators, and law enforcement are necessary to legalize the use of silkworms as edible insects. Recent EU food legislation has opened avenues for the use of edible insects in Europe, but comprehensive regulations are needed to ensure both producer and consumer safety. Detailed regulations can facilitate the growth and use of silkworm-based products while safeguarding consumer health and well-being.

Conclusion

Silkworms represent a promising solution to the global challenge of food scarcity and malnutrition. Silkworm larvae and pupae are highlighted for their high nutritional value and scalability in production. Their rich nutritional composition and therapeutic properties make them a valuable addition to the human diet. Despite their bioactive properties, further research is needed to fully understand their pharmaceutical mechanisms, with clinical trials necessary to confirm their medicinal properties. Currently, the production of silkworm-based food and pharmaceuticals is limited, and their use for human consumption is still in its early stages. However, studies indicate significant potential for silkworms in biomedicine, urging future research to explore their molecular pharmacological activities and conduct clinical testing to enhance human health.

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4. ENTOMOLOGY

Potential Scope of Agro Tourism in India

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Introduction

Agri Tourism in India is moving beyond traditional approaches of Tourism by introducing Agriculture Tourism to villagers. Agro-tourism is the practice of tourists or visitors coming to a farm to have an intimate and exclusive experience with agriculture. It's a chance for city people to relax and spend a few days away from the bustle of the city, learn something new, and enhance their mental well-being. Farmers can use it as a way to increase and diversify their revenue. Agro-tourism includes a broad range of activities, including hospitality and farm stays, recreation activities, farm tours, education about agriculture, interactive learnings direct-to-consumer sales, demo and showcases.

Sustainable Agro-Tourism in India

Sustainable agro-tourism involves traveling to and participating in rural communities and agro-cultural pursuits while honoring and protecting the area's natural and cultural resources.

Spreading knowledge and awareness: Both visitors and farmers must

understand the idea of sustainable agro-tourism, its advantages, and how to engage in it ethically and responsibly. Online platforms, media, workshops, and campaigns can all be used to accomplish this. Sharing successful stories, best practices, and difficulties related to agro-tourism in India and other nations can also be a part of education

Creating policies and guidelines: Clear and uniform rules and regulations are required for agro-tourism in India to guarantee the sustainability, safety, and high caliber of the facilities and services provided by the farmers. The government, trade associations, or other interested parties may create these standards and guidelines, which can address issues with waste management, pricing, marketing, infrastructure, and hygiene

Offering assistance and rewards: Farmers and local communities that participate in agro-tourism can receive assistance and incentives from the government and other organizations, including funding, subsidies, tax breaks, recognition, and training. These can assist them in overcoming the difficulties and dangers associated with agro-tourism as well as enhancing their infrastructure, income, and skill set

Encouraging networking and cooperation: Collaboration and networking between farmers, visitors, service providers, researchers, and policymakers can improve agro-tourism. Synergies, knowledge exchange, and access to new markets and opportunities can all be facilitated by doing this. Platforms, gatherings, and associations that bring together the different agro-tourism stakeholders can foster cooperation and networking

Advantages of Agro-Tourism

The agro tourism have play a major role income diversification of farmers, cultural exchange, creating awareness about the environment and ecology, rural area development and empowering the sustainable farmers livelihood, etc.,

Diversification of income: Agro-tourism gives farmers access to a second stream of income in addition to a direct marketing avenue for customers. Additionally, it increases the number of tourists and their average length of stay in a particular area, which benefits the tourism industry.

Cultural exchange: One excellent way to discover the genuine and varied facets of Indian rural life is through agro-tourism. It gives guests the chance to discover agricultural methods, regional cuisine, celebrations, handicrafts, and customs, as well as to enjoy the rich history and culture of rural India. Agro-tourism is a type of rural tourism that promotes the social and economic well-being of the surrounding communities by revealing the rural life, culture, art, and heritage in rural areas. Farmers can use it as a way to increase and diversify their revenue

Environmental awareness: By encouraging visitors to respect and preserve the natural resources, biodiversity, and ecology of rural areas, agro-tourism fosters sustainable and ethical travel. Additionally, it aids in mitigating the adverse effects of mass tourism on urban areas, including traffic jams, pollution, and crowding.

Development in rural areas: Through the creation of jobs, the improvement of skills, and the support of different services like lodging, entertainment, and transportation, agro-tourism promotes rural development. Additionally, it motivates farmers to cultivate otherwise unusable land and to showcase their goods, abilities, and expertise to tourists.

Real rural existence: Travellers can experience authentic and varied facets of Indian rural life through agro-tourism, including farming methods, regional cuisine, celebrations, handicrafts, and customs. It also aids in their appreciation of rural India's rich cultural legacy

Tourism that is ethical and sustainable: By encouraging visitors to respect and preserve the natural resources, biodiversity, and ecology of rural areas, agro-tourism fosters sustainable and ethical travel. Additionally, it aids in mitigating the adverse effects of mass tourism on urban areas, including traffic jams, pollution, and crowding

Farmers' livelihood and empowerment: Agro-tourism empowers and improves the livelihood of farmers by providing them with an additional source of income, employment, and market access.It also helps them to showcase their products, skills, and knowledge to the tourists, and to learn from their feedback and suggestions

Potential For Agro-Tourism In India By State

Diverse geographic areas: A state with a diversity of climates, ecosystems, and landscapes can provide a range of agro-tourism experiences, including beaches, islands, hill stations, forests, and deserts. For instance, the varied topography of Kerala, Goa, Karnataka, Tamil Nadu, and West Bengal draws tourists

Diversity in agro-culture: A state can showcase its agro-cultural heritage and culture to tourists if it has a diversified and rich agro-cultural sector, with crops, livestock, and high-value, unique, or organic products

Policy support: The development and expansion of this industry can be aided by a state that offers an agro-tourism policy environment that is both supportive and favorable, with well-defined and uniform standards, guidelines, incentives, and recognition.

Participation of stakeholders: A state can develop synergies, exchange knowledge, and gain access to new markets and opportunities if its agro-tourism stakeholder's farmers, tourists, service providers, researchers, and legislators are highly engaged and collaborative. Gujarat, for instance, intends to establish a Center of Excellence for agro-culture Tourism, educate and train farmers, and create policies and guidelines for agro-tourism

The Future of Agro-Tourism In India

Sustainable Rural Development: Because it creates jobs, particularly for locals and farmers, agro-tourism can play a major role in rural development. Agro-tourism can keep people in rural areas and discourage migration to cities as urbanization continues

Increasing the Variety of Income Sources: The income of the farmers may be at risk due to crop failures, market volatility, and climate change etc. The farmers may opt for a new variey of income i.e. the Agro-Tourism. In addition to traditional agri-culture, farmers can make additional revenue by providing guided tours, workshops, and farm stays etc. to the tourists and to the persons who would love to see the village life and agiculture.

Learning Opportunities: Agro-tourism raises public awareness of organic farming, sustainable farming methods, and biodiversity preservation. Agro-culture, animal husbandry, and rural life can be taught directly to families, schools, and colleges

Preservation of Heritage and Cultural Exchange: Travellers can experience regional cuisine, customs, and traditions through agro-tourism. It guarantees the survival of indigenous knowledge, crafts, and artistic expressions by preserving them

Policy Framework and Government Support: The Indian government has started initiatives to promote agro-tourism because it understands its significance. Policies that encourage farmers to engage in agro-tourism require more work.

5. AGRICULTURE ENTOMOLOGY

Nature *vs* Nurture: Sex and Caste Determination in Honeybees

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Introduction

Organisms have evolved a bewildering diversity of mechanisms to generate the two sexes. As early as 1845, Johan Dzierzon- a Polish theologist and one of the founders of modern beekeeping noticed that virgin queens

could only lay eggs that became drones and from this he deduced that male bees must be haploid. This early inference turned out to be basically true. The honeybee (*Apis mellifera*) employs an interesting system in which sex is determined by heterozygosity at a single locus (Sex Determination Locus - SDL) harboring the complementary sex determiner (*csd*) gene. Bees heterozygous at SDL are females, whereas bees homozygous or hemizygous are males (Mackensen, 1950).

The *csd* gene is the primary signal of sex determination in the *A. mellifera*. Fertile queens and sterile workers are alternative forms of the adult female honeybee that develop from genetically identical larvae following differential feeding with royal jelly. The fate of reproductive queens and sterile workers, a female larva's developmental largely depends on the diet it receives. Nutritional input, acts as an agent of epigenetic modifications leading to different developmental fates, with massive implications for reproductive status. Larvae fed exclusively royal jelly, a glandular secretion of nurse bees, become queens, whereas those fed royal jelly for 3 days and subsequently worker jelly containing honey and beebread become sterile workers. The differences in phenotype are thought to result from either worker castration *via* nutritional deprivation or queen enrichment by nutritional supplementation. Suboptimal nutrition demonstrably contributes to "trophic castration" and corresponding worker sterility; withholding sugars during the first 3 days of larval life promotes development of sterile worker. By contrast, queen-destined larvae consuming only royal jelly develop more rapidly and attain a larger adult body size than do worker-destined larvae.

Nature *vs* Nurture: Sex and Caste Determination in Honeybees

A worker and queen can theoretically be genetically identical. So, what makes one develop into a long-lived, regal queen, with her rounder face and large abdomen housing voluptuous ovaries, instead of a sterile worker? Logically, their genetic similarity should leave just one option: nurture. Different diets cause massive epigenetic changes to the DNA of worker and queen destined larvae and regulate key developmental genes. Queen fate is determined by specific feeding of the queen larvae with royal jelly (Kamakura, 2011).

Beye and colleagues created an inbred honeybee cross in which 50% of the offspring failed to mature because they were diploid males. By fine-scale mapping of a region between two genetic markers, the authors identified a 13-kb region that was always heterozygous in the females of the inbred cross. The isolation of the sex determination locus in honey bees led to the identification of the *complementary sex determiner* (*csd*) gene. The *csd* gene product is necessary for female development, because inactivation of *csd* gene product in female embryos causes a full switch into male development (Beye *et al.*, 2003). Well established gene hunting techniques confirmed the existence of three genes, besides *csd* and *fem*, in the locus - *GB11211*, *GB13727*, and *GB30480*. Repressing transcripts of these genes showed that none was involved in sex determination. In contrast, repression of *csd* or *fem* products in females resulted in development of male gonads, while repression of *csd* or *fem* products in males had no effect. Thus, *csd* and *fem* appear to be the only SDL genes involved in activating female-making machinery in honeybees (Gempe *et al.*, 2009).

Roth and colleagues have used clustered regularly interspaced short palindromic repeats (CRISPR) to knock out two key genes (feminizer and doublesex) that guide sexual development. The heterozygous *csd* genotype leads to expression of functional complementary sex determining proteins, which splice transcripts of a downstream gene, feminizer (or *fem*). The spliced Fem protein in turn regulates the splicing of doublesex (*dsx*) another downstream gene whereas the unspliced *fem* is not functional and leaves *dsx* unspliced as well. This cascade is key for proper female and male development (Roth *et al.*, 2019; Mcafee *et al.*, 2019).

Epigenetics means some factors other than genes govern the phenotype of an organism. In *A. mellifera* DNA methylation is a key component of an epigenetic network controlling a most important aspect of eusociality, the reproductive division of labor. It occurs at CG sites (Cytosine and Guanine),

established de novo by DNA methyl transferase 3 (DNMT3). Silencing the expression of *DNMT*3 results in individuals emerging as queens with fully developed ovaries. DNA methylation is used for storing epigenetic information, where the use of information can be differentially altered by nutritional input (Kucharski *et al*., 2008).

Attention has historically focused on royal jelly to identify constituents determining developmental fate. The major royal jelly protein royalactin (MRJP1), for example, acts via the epidermal growth factor receptor (*Egfr*) pathway, which determines cell proliferation, and insulin/insulin-like signaling (IIS)/target of rapamycin (TOR), which contributes to metabolism and growth. In addition, DNA methylation status of the genome affects caste differentiation; knockdown of DNA methyltransferase *Dnmt3* expression in neonates resulted in queen-destined larval development. Epigenetic processes bridge intrinsic and environmental signals through DNA cytosine-5-methyltransferases (Dnmts). Larval knockdown of DNA methyltransferase 3 (*Dnmt3*) causes development of queen-like traits in worker-destined larva. In bee larvae, nutrition modulates juvenile hormone III (JHIII) and 20-ecdysone titers via IIS/TOR and EGFR pathways to control caste differentiation. The fact that the *Egfr* pathway is responsible for 20-ecdysone synthesis suggests that its activation decreases development time for queen-destined larvae, Royalactin increased body size and ovary development and shortened developmental time in honeybees. It activates p70 S6 kinase enzyme, which is responsible for the increase of body size. Knockdown of epidermal growth factor receptor (*Egfr*) expression in the fat body of honeybees resulted in a defect of all phenotypes induced by royalactin. These findings indicate that a specific factor in royal jelly, royalactin, drives queen development through an *Egfr*-mediated signalling pathway (Kamakura *et al*., 2011).

Because all three *Dnmt* enzymes are shared by humans and honeybees but not by other commonly used model invertebrates, such findings establish the honeybee as a model to not only study the function of DNA methylation in invertebrates, but also for examining any fundamental overlaps that may help in understanding the nutritional basis of epigenetic reprogramming in humans.

Future Prospects

The complementary mechanism of sex determination enables females to control the sex (female-to-male) ratio, ensuring outbreeding and achieving a close mother-daughter genetic relationship, features which have facilitated the evolutionary transition to sociality in bees, ants, and wasps. Since, inbreeding brings lethal alleles and lowers brood viability, colony population and honey production, should be carefully avoided in commercial beekeeping practice by criss - crossing. Several fundamental aspects remain unknown. Future research, investigating these aspects will guide us to understand novel control mechanisms and their evolutionary origin.

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6. ENTOMOLOGY

Modern Methods of Propagation Techniques in Horticulture Crops

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Plant propagation refers to the multiplication of an individual plant or group of plants, which have specific value to mankind, perpetuation of plants is called propagation.

Broadly two types of propagations are practicing:

- Sexual (Seed propagation)
- Asexual (Vegetative propagation).

Sexual Propagation: Plants are multiplied by using seeds.

There are some disadvantages in sexual method of propagation they are as follows:

- Seedling trees generally owing to genetic regeneration in heterozygous plants, seedlings are not uniform in their growth, yielding capacity and fruit quality composed & asexual propagated plants
- Seedlings trees take more time to come to bearing than grafted plants.
- Seedling trees, being very large, pose problems for efficient management of orchards trees.
- It is not possible to derive the benefits of root stocks.
- Continuous seed propagation leads to inferiority in progeny.
- Sexually propagated plants have long Juvenile period.
- Choice or chance trees or hybrid trees cannot be multiplied true to type because of segregation of characters.
- Seed loose viability within a short period. Ex: Citrus, Mango, Jack, Papaya, Jamun etc.

Asexual Propagation:

It is also known as vegetative propagation means propagation of plants without using seeds mainly used for large scale and uniform multiplication of fruit crops and also to obtain true to type of plants as same as that of mother plant.

The main advantages of asexual propagation are:

- To obtain true to type of plants.
- Asexual propagated plants are early bearing in nature.
- Vegetative propagated plants are more vigorous than seed propagated ones.
- Benefits of root stocks and scions are exploited through asexual means.
- Vegetative propagated plants are more precocious in bearing.
- Certain injuries can be repaired by means of bridge grafting through asexual propagation.

Considering the demerits of seed propagation and merits of vegetative propagation, asexual propagation is the best suited for modern method of propagation in fruit crops.

The different types of modern methods of propagations are:

- Cuttings
- Budding
- Layering
- Grafting

Cuttings

The different types of cuttings are as follows:

A.Hard Wood Cuttings: One year old and mature shoots are selected for the purpose of propagation. The selected shoot should be healthy and should not be a vigorous growth. The length of the cutting is kept 10-45 cm. Cutting must possess at least two to three buds. The lower cut is made round just below the node and the upper cut is given about 1 to 2 cm above the upper node is slanting manner. Cutting in this manner helps in identifying

lower and upper portion of cutting. The lower portion planted in the soil. Cuttings are to be taken during Nov-Feb. Before commencement of sprouting the point of which scion is joined at root stock is timed as matrix.

B. Semi Hard Wood Cuttings: Take 4-9 months old shoots of semi hard wood mature is used for raising new plants. Shoots of 7-20 cm length are used for preparing cutting. IBA rooting hormone is used for better rooting. Cutting is prepared during rainy season (June - July). High humidity during season prevents drying of cutting. Mist chamber also provides suitable growing conditions for such type of cuttings.

C. Soft Wood Cuttings: Shoot of 2-3 month age are selected for soft wood cutting, the length of cutting is 10-15 cm. Apple, Peach, Guava and many ornamental plants can be propagated under mist chamber using soft wood cutting.

D. Herbaceous Cuttings: Ornamental plants are planted through herbaceous cutting, shoot of 1-2 months age are selected for cutting.

Budding:

The process of connecting scion, which has a bud and root stock in a manner such that they may unity grow successfully as one plant is termed as budding.

A. Patch Budding: This method is very successful for propagation of plants having comparatively thick bark. The bud is placed on root stock for placing bud an incision of 2-3 cm size is prepared. Polythene tape was wrapped on bud leaving the sprouting portion. Wrapping prevents desiccation of bud and then favor sprouting.

B. Chip Budding: This method is practices during the period when there is lack of sap flow and bud does not slip out easily from the bark. The bud is taken out from the scion shoot along with wood similar size and incision is made on the root stock and it is wrapped with polythene tape.

C. Ring Budding: Ber, Peach can be propagated using this method; in this method ring shaped bark of 2.5-3 cm is taken for budding.

Grafting

Grafting is a technique of propagation in which scion stick and root stock is connected in a manner such that they may control and subsequently grow and develop as a successful plant.

a) Approach Grafting: Two independent plants on their own roots are grafted together (self-sustaining).

Ex. Guava, Mango, Sapota.

b) Veneer Grafting: This is also a kind of side grafting slight modification. It is widely for grafting small potted plants and *insitu* grafting.

Ex.Avocado,Mango, etc.

c) Epicotyl/Stone Grafting: This method of grafting is done on the epicotyls region of the ground seedlings; hence the name epicotyls grafting.

Ex.Cashew, Mango, etc.

d) Soft Wood Grafting: The technique of soft wood grafting is similar to that of cleft or wedge grafting. In this case, grafting is done on newly emerged flush having bronze coloured leaves and stem. This method is *insitu* grafting. The scion wood to be used should be defoliated 8-10 days period to the grafting and having some thickness as that of terminal shoots. The graft should be secure firmly using poly house strip.Ex. Mango, Sapota. Jack .

e) Top Working: Top working for changing a variety is generally done as long lived species, growing in a healthy condition. Short lived species, old trees or diseased trees are not suitable for top working; in such cases new planting is considered more economical and useful from top working.

Micro-propagation

Growing plant parts from meristem tip, shoot tip, embryos, anthers, axillary buds under controlled environmental condition like temperature, relative humidity and light in an artificial nutrient media is known as micro-propagation.

Advantages of Micro Propagation:

- Requires relatively small growing space.
- The technique of micropropagation is applied with the objective of enhancing the rate of multiplication.

- Through tissue culture over a million plants can be grown from a small, even microscopic, piece of plant tissue within 12 months.
- Shoot multiplication usually has a short cycle (2-6 weeks) and each cycle results in logarithmic increase in number of shoots.
- Tissue culture gives propagules such as mini-tubers or micro-corms for plant multiplication throughout the irrespective of the season.
- The small size of propagules and their ability to proliferate in a soil free environment facilitate their storage on a large scale ability to proliferate in a soil free environment facilitate their storage on a large scale and also allows their large scale dissemination by suitable means of transport across international boundaries.
- Stocks of germplasm can be maintained for many years.
- Pathogen free plants can be raised and maintained economically.

Ex. Banana, Pomegranate, Strawberry.

7. ENVIRONMENAL SCIENCE

Environment Protection: Need, Role of Different Parties and Suggestions

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Introduction

Dictionary meaning of environment is the conditions in which one lives or works. It also means the natural world of land, sea, air, plants and animals that exist around.

Thus, the environment is the combination between all biotic and abiotic components.

The environment, therefore, is something which is our surroundings and nature. This is something where all living and non -living organisms live together. Both living and non-living things have connections together and are interdependent so far as maintenance of balance in eco system is concerned. The living organisms include the human being, animals and trees etc. whereas the non-living elements of environment are air, water and land etc. The components make it very clear that the living and non-living elements are interdependent and a proper balance has to be maintained. If we fail in this then the same may result in some disasters and destructions which we have witnessed in the past and are witnessing in present too.

We know, the environment is the most precious gift of our nature. It is, therefore essential that we take care of the environment in the best possible manner; we should not disturb the balance of ecosystem where we are naturally dependent on each other for our own survival, we should carry out activities in such a way that we do not harm the environment either intentionally or unintentionally.

Types or Components of Environment

The environment is basically divided in two components or classes' viz. physical components and biological components.

The physical components comprise the atmosphere, lithosphere and hydrosphere. The examples of physical components are air, natural vegetation, soil, water, sea, ocean etc. The biological element, on the other hand, comprises human beings and other living organisms.

In order to keep the proper environmental conditions we are duty bound to keep equilibrium in ecosystem. We should not indulge in any activity which may disturb any of the components since the disturbance in environmental system may result into adverse effect on the nature.

If we look into our surroundings we find that the environmental challenges have increased a lot and it is need of the hour to protect our planet. If we do not pay proper

attention towards this we may face more and more crisis in time to come. We read and hear and witness too that due to natural imbalances some parts of the globe are facing disasters and calamities in the form of flood, acute heat, low production of food grains, deaths of habitats etc. These effects are nothing but result of imbalance in eco system and our carelessness. These things have adversely affected the environment.

The humanity is facing crisis like climate change, biodiversity losses etc. which have endangered even the life on the planet earth. However, even in this condition of darkness we should not loose hopes. It is late but not too late to begin work on environment protection. We should make ourselves understand the significance of environment protection and in addition we should make others understand the importance of environment balancing. If this is not done, the humanity will face more and more crisis in future and the next generation will certainly blame us for this imbalance.

Thus, environment protection is must. The need and role of different sections of the society shall be focused on in this article along with the suggestion for ecological balances.

We shall explore the importance of environment protection in this article and shall also try to summarize the actionable steps which may be taken individually, by communities and by the Governments.

Urgency or Need for Environment Protection:

We know, we are very late but we are not at the stage where we cannot do any things. It is said better late than never so following this phrase we should immediately start working for environment protection. We cannot exaggerate the urgency of environment protection. It is need of the hour now looking to the climate change, greenhouse gas emissions from different human activities etc. The destruction of ecosystem is result of these activities (gas emissions and climate change etc.). The nature creates havoc sometimes and we find ourselves helpless. This destruction is nothing but a warning from the nature to human being, to take care of the environment. If we remain careless, as we are, even after such disasters, we may face more adversities and calamities in near future. The climate change has caused a change in weather pattern all over the globe and has weakened the people worldwide. Currently, if we talk of our country, we find that many parts of the country are facing scorching heat and in some state the temperature has crossed even 50 degree. These are the visible crisis which humanity is facing. Who is responsible for this? Certainly we, the human being, are responsible. We are not at all vigilant. This is nothing but result of our careless attitude towards environment protection. Similarly overexploitation of available natural resources is also one of the important reasons of environment destruction. There is a competition to earn more and more money without taking care of the availability of the natural resources. The scorching heat, the heavy rains and floods, earthquake, cyclone etc. are all sign of disturbances in natural system of environment. These things are destroying the species at an alarming rate resulting in disturbance in ecosystem. A recent study has claimed that if the temperature crosses 56 degrees then most of the species will die. What impact this situation will have should be taken care of right now. In some parts of our country we observed, in this season only, temperature of more than52 degrees in Delhi and more than 54 degrees in Nagpur (as reported in different newspapers and sites). Thus, the time is not far away when we shall see temperature of more than 56 degrees. Think what will happen then? Will it not be difficult, even for the human being, to survive? Will it be a good atmosphere for species and animals? The answer is certainly no in absolute terms. When we know this, then why not we begin working for environment protection, why to remain careless. If we remain careless and are not vigilant now, we shall only be responsible for these ecological imbalances. If the environment is kept in balanced manner then only we will survive. Our own survival is at stake. So, be alert, be vigilant and take care of the environment.

Who Can Protect Environment?

The God has given brain and all kind of understanding power to human being and so this section of the living things has more responsibilities to protect the environment. The work can be done individually, as a

community or as a Government.

The Role of Individuals

An individual has got a mindset that if he alone put efforts then nothing will change and the things would remain as they were. Thus, he does not do anything with this perception and wait for others to take initiation which normally does not happen. So one should understand own capabilities and should exercise significant power to fight for the environment protection. It is not so that his efforts will change everything but certainly some changes will be there and with the following steps one can take initiation for environment balancing:

1. Change the lifestyle and bring the same to simplicity;
2. Reduce the energy consumption to the extent possible;
3. Reduce the use plastics in daily and routine life;
4. Opt sustainable products;
5. Bring awareness in the nearby locality or the society for cleanliness and plantation etc.;
6. Support the good environmental policies;
7. Embrace the conservation and protective mindset so far as environmental conditions are concerned;
8. Adopt the eco-friendly products and practices;
9. Educating children about the significance and importance of environment;
10. Using public transport to reduce air pollution;
11. Planting of trees;

The above steps of individuals will certainly protect the environment and one's doing these things will give a sense of feeling of accomplishment of his or her part in environment protection. A sense of self-satisfaction will also be there.

Role of Communities

Teamwork is very essential to achieve any goal or to win the match. If the environment protection becomes the object of the people and if they start taking the task with team spirit then nothing can stop them to achieve this goal. They can certainly contribute substantially to protect the natural balance. The collective effort or the team effort is nothing but effort of communities. Therefore, the role of communities is very significant and the engagement and teamwork of communities certainly play a very important part in environment protection. There are certain initiatives which the communities should take for the purpose. The following are the important steps which the communities should take for environment protection:

1. Reduce the wastage;
2. Reuse and recycling of wastage in such a manner that the pollution is reduced;
3. Educate the individuals to participate in and volunteering in cleaning process;
4. Water conservation and increasing plantation;
5. Educate members of the society to minimize the use of plastics, specially the single use plastics;
6. Optimum utilization of energy;
7. Mobilization of community resources for ecological balancing;
8. Development of community gardens and commencement of new and innovative ideas for recycling;

Role of Government

Sometimes it may be happen that in order to safe guard the humanity certain hard steps need to be taken and the implementation of these steps to be done forcefully. This can neither be done by individuals nor the communities. The Government and the Government agencies play their part in this. Only the Government can from the policies and procedures and can get the same implemented in right spirit. The Government can play its role by framing such policies which encourages the environment protection. It should give shape to the policies and regulations in such a manner that the ecological imbalances do not happen. We can understand importance of role of Government in environment protection with following:

Earlier we have witnessed that in so many cities, all over the country, the high rise buildings were constructed by removing the trees and green areas. We have also seen that the builders and construction agencies did not plant trees etc. in the proportion in which the same were cut or removed. This resulted in reduction of green areas and development of concrete and cement buildings in most of the

tier one and two cities of our country. These regularized or non-regularized buildings reduced the greenery to a great extent which consequently damaged the environmental conditions. The Government found itself helpless and could not control the situation as there was no strict rules and regulations available for controlling these builders and developers. The Government took note of it and started working on controlling this haphazard development. It brought a new Act viz. **Real Estate (Regulation and Development) Act in 2016**. The Act has very strict provisions and made it compulsory for the developers to take environmental clearance. It has made it mandatory for the developers to plant trees and made a provision that one tree is to be planted for every 80 sq. meters of land. Similarly required provisions have been incorporated in the Act for solid waste management, for keeping the air quality and for controlling noise pollution. Besides, the RERA has emphasized on the rain water harvesting, energy efficiency and development of green and renewable energy etc. In case the builder fails in complying with the provisions of the Act then he may face difficulty in getting environment clearance which consequently will have adverse effect on the project. The builder is not allowed, in such case, to sell the flats, offices etc. in the project. The strict provisions have ensured compliance and we now find proper environment balancing in such buildings and in surrounding areas.

Thus, we can say that the action and the policy formation by the Government too play a very vital and pivotal role in environment protection. They have the powers to shape the policies, they have the powers to get those policies and procedurs implemented in proper manner to ensure that the environment imbalances do not happen.

The Government can play its role in the following way for environment protection:

1. By encouraging investment in renewable energy the government can reduce the pollution level to a great extent;
2. Enacting standard emissions standards;
3. Development in the field of green energy, like solar power, wind energy and bio energy, which does not pollute the environment;
4. Bilateral and multilateral agreements at global level to meet the environment challenges;
5. Prioritizing the sustainability and environment protection in Government policies;

Conclusion

In summary we may state here that the humanity at global level is facing unprecedented environmental imbalances. Somewhere the rains are irrepressible; somewhere the heat waves are beyond tolerance. Extraordinary environmental threats are giving warning signals now. We have no option except to work, on top priority basis, towards protecting our planet from such unprecedented and extraordinary events. This can only be done with the co-ordination, co-operation, combination and collective efforts of the individuals, communities and the Government. With the joint efforts of all we can be more sustainable and resilient. We must understand that if we fail in keeping the ecological balances, we will certainly have a very non workable and bad environment. This will bring nothing but disasters and destructions. So everyone should come forwards and start adopting eco-friendly life style, start favouring policy reforms in the fight for environmental protection. Together, we can do. We should rise and accept the challenge of safe guarding the precious gift of the nature to the earth where we are living. It is advantageous not only for us but for our future generation too.

Suggestions

The following suggestions are there for environment protection:

1. Reduce, Reuse, and Recycle so that the waste could be minimzed.
2. Reduce the use of plastic products;
3. Adoption of energy conservation;
4. Conservation of water;
5. Wildlife conservation;
6. Use of sustainable products;
7. Adoption of practices to reduce carbon footprints;
8. Protection of natural habitats;
9. Promotion of renewable energy;
10. Educate and bring awareness among people at society level for environment

protection.

8. SOIL SCIENCE

Exploring the Components and Impact of Integrated Nutrient Management

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Introduction

Integrated Nutrient Management (INM) is an approach to managing plant nutrients by combining various sources and methods to optimize nutrient availability for crops. The goal of INM is to enhance crop productivity and sustainability while minimizing negative environmental impacts. The INM is a flexible method that minimizes use of chemical sources of nutrients and maximizes farmer's profits. The use of integrated plant nutrient supply and management strategies to improve soil quality, input efficiency and crop productivity is extremely important for improving the food and nutrition security of Indian agriculture (Swarup, 2010). Basically, use of organic manure in addition with inorganic fertilizers are needed to improve soil health (Prasad *et al*., 2010). Under continuous farming, only chemical fertilizers or organic fertilizers cannot maintain the required level of crop production. Comprehensive nutrient management is very important, not only to maintain high yields over the years (Verma *et al*., 2010), but also to improve soil health and ensure a safer environment.

Components of Integrated Nutrient Management

- **Legumes:** Legumes play a crucial role as a component of Integrated Nutrient Management (INM) due to their ability to fix atmospheric nitrogen through a symbiotic relationship with nitrogen-fixing bacteria, a process known as biological nitrogen fixation. Leguminous plants, such as peas, beans, lentils, and clover, host nitrogen-fixing bacteria in their root nodules, converting atmospheric nitrogen into a form that is readily available for plant uptake. This nitrogen fixation not only enhances soil fertility but also reduces the reliance on synthetic nitrogen fertilizers, mitigating environmental impacts associated with their production and use.
- **Inorganic Fertilizers:** Inorganic fertilizers are a significant component of Integrated Nutrient Management (INM), contributing essential nutrients to plants in a readily available form. These fertilizers, typically synthesized through industrial processes, provide a quick and targeted supply of specific nutrients such as nitrogen (N), phosphorus (P), and potassium (K), along with various micronutrients. In the context of INM, inorganic fertilizers are often used judiciously and strategically alongside organic inputs to achieve a balanced and sustainable nutrient management system. By supplementing organic inputs with inorganic fertilizers, farmers can tailor nutrient applications to meet the precise needs of crops, optimizing nutrient use efficiency. This targeted approach helps enhance crop yields without over-relying on organic inputs alone, providing a more immediate and controlled nutrient supply.
- **Organic Manures:** Organic manures are a fundamental and beneficial component of Integrated Nutrient

Management (INM), playing a vital role in enhancing soil fertility and promoting sustainable agricultural practices. Organic manures are derived from natural sources such as animal waste, crop residues, green manure, and compost. Organic manures provide a slow-release and well-balanced supply of essential nutrients, including nitrogen, phosphorus, potassium, and micronutrients. Organic matter in manures enhances soil structure by promoting aggregation and improving water retention and drainage. Organic manures also support a diverse and active microbial community in the soil. Microorganisms play a crucial role in nutrient cycling, breaking down organic materials into plant-available forms and enhancing soil fertility. By relying on organic manures, farmers can reduce their dependence on synthetic fertilizers, thereby minimizing the risk of nutrient runoff and water pollution.

- **Crop Residues:** Crop residues, comprising the leftover plant materials after harvest, are a valuable and versatile component in Integrated Nutrient Management (INM). These residues, which include stems, leaves, and other plant parts, can be strategically managed to enhance soil fertility, improve organic matter content, and support sustainable agricultural practices. Crop residues are rich in organic matter, and when incorporated into the soil, they contribute to the improvement of soil structure, water retention, and nutrient-holding capacity. Crop residues contain essential nutrients that plants have absorbed during their growth. Returning these residues to the soil allows for the recycling of nutrients, promoting nutrient-use efficiency and reducing the need for external inputs.
- **Biofertilizers:** Biofertilizers are living organisms that enhance plant growth by promoting nutrient availability through various mechanisms. These microorganisms, which include bacteria, fungi, and algae, are an important component of Integrated Nutrient Management (INM). Nitrogen-fixing bacteria, such as Rhizobium and Azotobacter, are common biofertilizers. They form symbiotic relationships with leguminous plants or reside in the soil, fixing atmospheric nitrogen into a form that plants can use. Phosphate-solubilizing bacteria, like Pseudomonas and Bacillus species, release phosphorus from insoluble compounds in the soil, making it more available for plant uptake. Certain biofertilizers, such as potassium-solubilizing bacteria, play a role in releasing potassium from minerals in the soil. This contributes to improved potassium availability for plants, promoting healthy growth and stress resistance.

Limitations of INM

The initial investment required for equipment, organic inputs, and farmer training can be a financial burden, potentially limiting the adoption of INM practices, particularly in resource-constrained regions. The time-consuming nature of some INM practices, such as incorporating green manure crops or waiting for organic materials to decompose, may affect timely planting and harvesting schedules.

Conclusion

Integrated Nutrient Management emerges as a pivotal strategy for promoting sustainable agriculture in India. The synergistic integration of legumes, inorganic fertilizers, organic manures, crop residues, and biofertilizers not only optimizes nutrient availability but also fosters long-term soil health. The benefits include reduced dependence on synthetic fertilizers, improved water retention, and a more resilient farming system. However, the implementation of INM is not without challenges. Financial constraints, time-consuming practices, and variability in outcomes underscore the need for careful adaptation and monitoring. Overcoming these limitations will be crucial in realizing the full

potential of INM, ensuring food and nutrition security while safeguarding the environment in the ever-evolving landscape of Indian agriculture.

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9. ENTOMOLOGY

Push-Pull Strategy in Integrated Pest Management

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Introduction

Push-Pull Strategy is also called as Stimulo-deterrent diversion. It is a strategy where a host-plant attractant(s) and a repellent(s) are used in combination, tested using a repellent intercrop and an attractant "trap" plant. Insects are repelled by volatiles emitted from the intercrop (push) and simultaneously attracted by volatiles from the trap plant (pull). The most successful work on push-pull to date has been conducted in Africa to control stem borers in maize and sorghum (Cook *et al*., 2007). Works not only by decreasing stem borer damage to maize, but also by enhancing the efficacy of natural enemies. Push-pull strategies maximize efficacy of behavior manipulating stimuli through the additive and synergistic effects of integrating their use (Franca et al., 2020). Eg: Stem borers of sorghum and maize are controlled by planting repellent non host intercrops like Napier grass (Khan et al., 2000). Push-pull strategies use a combination of behavior-modifying stimuli to manipulate the distribution and abundance of pest and/ or beneficial insects for pest management. By orchestrating a predictable distribution of pests, efficiency of population-reducing components can also be increased. The strategy is a useful tool for integrated pest management programs reducing pesticide input.

Integration of push-pull strategies with population-reduction methods

The push-pull strategy can easily be incorporated directly into IPM strategies involving generic insecticides. However, less environmentally harmful and more intrinsically benign alternatives are preferred. Insect growth regulators, and botanical insecticides such as neem, have potential use in push-pull strategies. The endotoxins of *Bacillus thuringiensis* (Bt) and spinosyn (spinosad) isolated from *Saccharopolyspora spinosa* are commercially available as insecticides, as are genetically modified crop plants expressing the gene for the Bt toxin. Biological insecticides based on entomopathogenic nematodes, fungi, bacteria, and viruses are used in IPM, but to date few push-pull strategies have used them.

Push-Pull Strategies in Subsistence Farming

The most successful push-pull strategy, currently used in practice, was developed in Africa for subsistence farmers. Directed at resource-poor farmers, and applied to organic or low-input agricultural systems, Control of stem borers in maize and sorghum. Maize and sorghum are principal crops in eastern and southern Africa, and lepidopterous stem borers, e.g., *Chilo partellus, Eldana saccharina, Busseola fusca, and Sesamia calamistis*, cause yield losses of 10% to 50% (Mazzoni and Anfora, 2021).

Thousands of farmers in east Africa are now using push-pull strategies, it involve the combined use of intercrops and trap crops, using plants that are appropriate for the farmers and that also exploit natural enemies.These plants were selected following trials in Kenya of potential host and nonhost plants. Stem borers are repelled from the crops by repellent nonhost intercrops, particularly molasses grass (*Melinis minutiflora)*, silverleaf desmodium *(D. uncinatum*), or greenleaf desmodium (*D. intortum*) (push), and are concentrated on attractive trap plants primarily Napier grass (*Pennisetum purpureum*) or Sudan grass (*Sorghum vulgare sudanens*e) (pull). Molasses grass, when intercropped with maize, not only reduced stem borer infestation, but also increased parasitism by *Cotesia sesamia*. Molasses grass showed attractive compounds similar to those found from maize but, in addition, identified five other compounds including (E)-β-ocimene and (E)-4,8-dimethyl-1,3,7-nonatriene. Desmodium intercrops also produce these compounds, together with large amounts of other sesquiterpenes and furthermore, when intercropped with maize or sorghum, suppress the parasitic African witchweed (*Striga hermonthica*), a significant yield constraint of arable land in the savannah region. A trap crop of Sudan grass also increased the efficiency of stem borer natural enemies. Although stem borers oviposit heavily on Napier grass, it produces a gummy substance that restricts larval development, causing few to survive. The push-pull strategy has contributed to increased crop yields and livestock production, resulting in a significant impact on food security in the region (Khan et al., 2000).

Push-Pull Strategies in Intensive Arable Agriculture

Control of Helicoverpa armigera in cotton

Helicoverpa species are polyphagous lepidopterous pests of a wide range of crops. The potential of combining the application of neem seed extracts to the main crop (push) with an attractive trap crop, either pigeon pea (*Cajanus cajan*) or maize (*Z. mays*) ('pull') to protect cotton (*Gossypium hirsutum*) crops in Australia from *Helicoverpa armigera* and *H. punctigera* has been investigated. Trap crop efficiency was increased by application of a sugar-insecticide mix. In trials, the push-pull strategy was significantly more effective than the individual components alone and reduced the number of eggs three days after application. The potential of this strategy was supported by a recent study in India. Neem, combined with a pigeon pea or okra (*Abelmoschus esculentus*) trap crop, was an effective strategy against *H. armigera*. The nuclear polyhedrosis virus of *H. armigera* was tested on the trap crop in place of insecticides, but this had little effect. Such a strategy could be used to manage insecticide resistance in *H. armigera* (Cook et al., 2007)..

Control of Sitona lineatus in beans

Sitona lineatus, the pea leaf weevil, is a pest of field legumes in Europe, the Middle East, and the United States. Adult feeding reduces leaf area, while larvae damage the nitrogen-fixing root nodules. Commercially available neem antifeedant (push) and synthetic aggregation pheromone 4-methyl-3,5-heptanedione released from polythene dispensers (pull) were tested as components of a push-pull strategy for *S. lineatus* in field trails using fava beans (*Vicia faba*). Both components altered the abundance and distribution of weevils as predicted. The neem antifeedant was as effective as the insecticide control treatment in reducing the abundance of weevils, but repeated applications were necessary to maintain efficacy (Cook et al., 2007).

Control of the pollen beetle in oilseed Rape

A push-pull strategy based on an attractive trap crop is being developed to protect oilseed rape (*Brassica napus*) from its specialist pests. Turnip rape (*Brassica rapa*) is a preferred host for several oilseed rape pests. Simulations using a spatially explicit individual based model indicated that a perimeter trap crop was the most appropriate arrangement. In field trials, a perimeter turnip rape trap crop significantly reduced the abundance of the pollen beetle (*Meligethes aeneus*) in spring-sown plots of oilseed rape compared with plots without a trap crop. Growth stage-related visual and olfactory stimuli were at least partly responsible for the preference for turnip rape by *M. aeneus* (Cook et al., 2007).

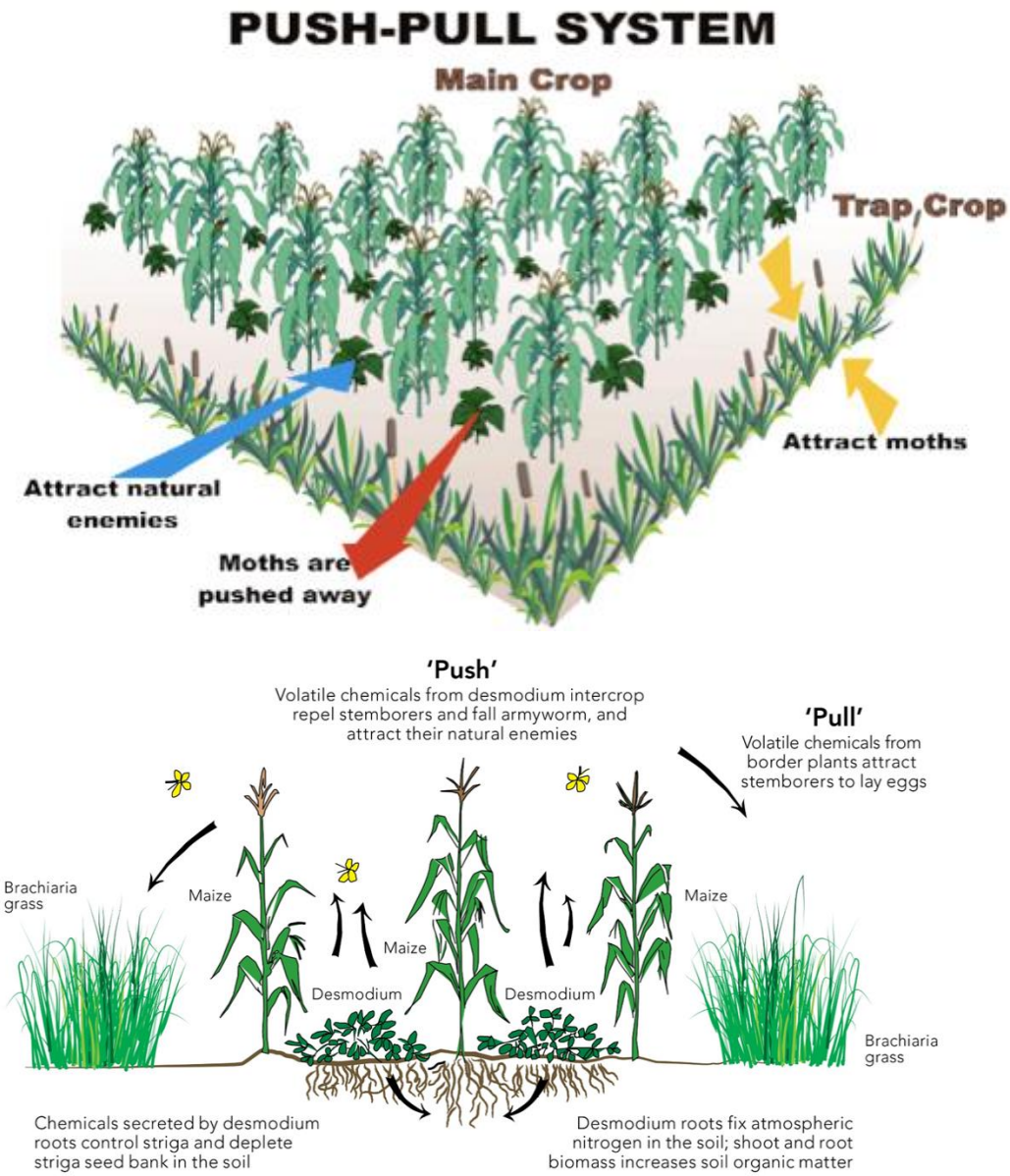
Advantages

- Resistance management.
- Increased efficiency of population reducing components.
- Increased efficiency of individual push and pull components.
- Improved potential for use of antifeedants and oviposition deterrents.

Disadvantages

- Limitations to development.
- Registration
- Limitations to adoption

PUSH PULL STRATEGY



Conclusion

Insect pheromone-related technologies for monitoring endemic pest populations, detecting invasive species, mass trapping for population suppression and mating disruption have had a relatively recent history of development in IPM compared to biological control and insecticide technologies.

plant allelochemicals aim at reducing the quantity of synthetic pesticides used in crop protection in order to decrease environmental hazards and promote a sustainable agriculture.

The push-pull strategy is a behavioral manipulation method that uses repellent/deterrent (push) and attractive/stimulant (pull) stimuli to direct the movement of pest or beneficial insects for pest management.

Stimuli used for behavioral manipulation in push-pull strategies include visual and semiochemical cues or signals that work by nontoxic mechanisms.

Strategies are therefore integrated with other population-reducing methods. Sustainable and environmentally sensitive components are favored, and the use of insecticides can be reduced.

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10. ENTOMOLOGY

Junctional Contacts and Membrane Organigation - Plasticization of Insect Cuticle

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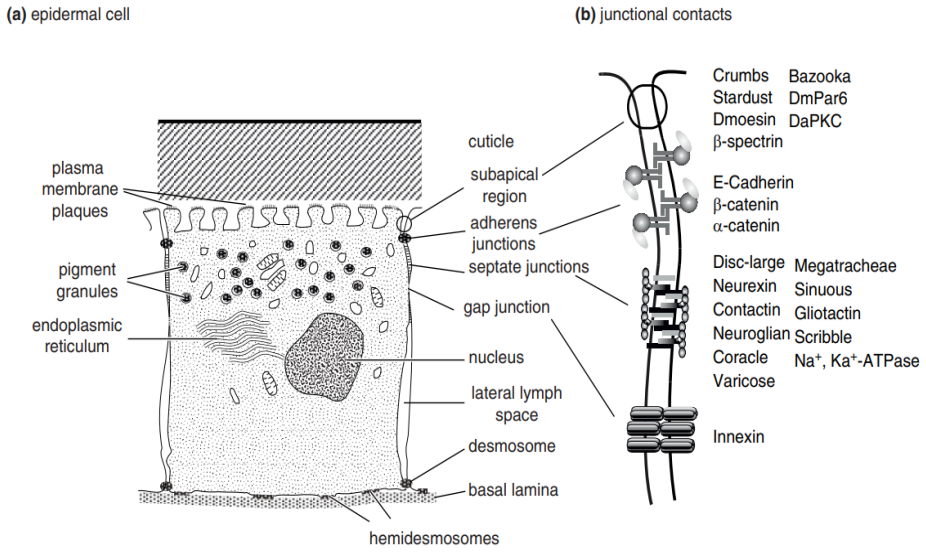
Membrane organization and junctional contacts

Polarized cells with distinct protein compositions in their apical, subapical, and basolateral membrane domains comprise the epidermis. Membrane proteins like Stranded-at-second, a potential cell surface receptor, or Yellow protein, an extracellular space-secreted dopachrome-converting enzyme, are examples of membrane proteins found in the apical domain of the embryonic epidermis and are often used as markers for this membrane region. Two protein complexes important in establishing and/or maintaining epithelial polarity are present in the subapical domain.

One of these complexes in Drosophila is made up of the common protein kinase DaPKC along with Bazooka and DmPar6, both of which include PDZ domains that mediate protein–protein interactions. The components of the other subapical region complex are stardust, b-spectrin, dmoesin, and crumbs. Through its short cytoplasmic tail, the transmembrane protein Crumbs attracts the guanylate cyclase Stardust, the actin-binding proteins Dmosein and b-spectrin to the membrane. The proper assembly of junctional complexes is dependent on the protein complexes found in the subapical region (Chapman, 2014).

Cell connection creation is an essential stage in the development of the epidermis because it guarantees proper tissue organization and function. Below the subapical area, a variety of junctional contacts hold epidermal cells together. These contacts not only mediate adhesiveness but also impede the passage of tiny molecules and promote

intercellular communication. Two different junctional complexes regulate cell–cell adhesion in the epidermis: more apical adherens junctions (zonula adherens) and more basal septate junctions (homologous to vertebrate tight junctions). Several transmembrane, scaffolding, and actin-binding proteins combine to produce these junctions (Wriggleswoth, 1974).



Transmembrane cell adhesion protein E-cadherin, which has a large extracellular domain mediating homophilic interactions, and the cytoplasmic protein b-catenin, which binds to the cytoplasmic region of E-cadherin and can also bind the a-catenin that connects the complex to actin filaments, are the main components that form adherens junctions. The Nectin–Afadin complex is linked to adherens junctions and controls epithelial organization in addition to this complex (Chapman, 2014).

A ladder-like arrangement of crossbridges that span the 20 nm space between the basolateral membranes of the adjacent epidermal cells is a characteristic of septate junctions. With the exception of tricellular contacts, when a septate junction's continuity is broken by channel-like structures across the epithelium and serving an unidentified purpose, they wrap the epithelial cells as a continuous belt. Compared to adherens junctions, septate junctions seem to have a more complex structure. They consist of three transmembrane cell adhesion proteins (Neurexin, Contactin, and Neuroglian) that together form a tripartite extracellular complex seen in both epidermal cells and neural tissue. Septate junctions localize to the Naþ, Kþ-ATPase, another transmembrane protein that is crucial to the paracellular diffusion barrier function of septate junctions. This protein is known to be involved in promoting epithelial transport. Coracle and Varicose, two scaffolding proteins, bind to Neurexin's cytoplasmic domain and limit its lateral mobility within the basolateral membrane, which may aid in the organization of the junctional complex. For the production of septate junctions, a number of extra cytoplasmic proteins are necessary, including Scribble, Gliotactin, Disc-large, Sinuous, and Megatrachea (Wrigglesworth, 1974).

Due to their similarities to vertebrate claudins, which are essential for the paracellular electrolyte transport in various epithelia, the latter two proteins have drawn a lot of attention. It doesn't seem likely, though, that they are true functional homologs. Yurt is another protein that organizes the basolateral membrane by interacting with septate junction

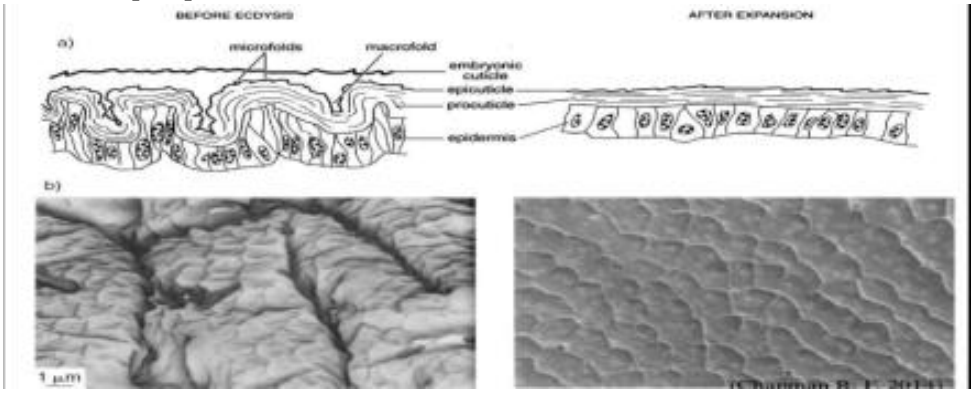
proteins. It has been demonstrated that in addition to establishing and preserving epithelial polarity, it also inhibits the passive diffusion of molecules larger than 10 kDa.

Adjacent cells are no longer closely linked to one another at higher distances from the cuticle, and the areas between them—known as lateral lymph spaces—are partially segregated from the hemolymph by desmosomes near the basement membrane. Epidermal cells form gap junctions that facilitate the transport of low molecular weight molecules (<1 kDa), including ions and metabolites (e.g., inositol phosphates, cyclic nucleotides). They are composed of several innexins (analogs of vertebrate connexins), which can also be organized as hexamers to generate heteromeric hemichannels. Eventually, two of these hemichannels from adjacent cells dock together to produce a channel that joins the two cells.

Gap junctions improve cell-to-cell cooperation. Integrins that interact with basement membrane components specify the most basal domains of the epidermis. Research on Drosophila's genetics has shown that the proteins located in various membrane domains are extremely dynamic structures, whose creation and upkeep are interconnected. Additionally, junctional complexes are essential for polarizing epidermal cells during development. This process follows a general course, which is started by the activity of genes already expressed in the early embryo, despite possible variances amongst various insect species. In Drosophila embryos, the earliest indications of polarization are seen during cellularization, when transitory junctions including junctional proteins such E-cadherin, a/b-catenins, and Disc-lost are formed. Later, more protein complexes along the apical–basal axis form successive subdomains to reinforce polarity.

Plasticization

- Expansion /streching of the new cuticle is plasticization. Serotonin (5-HT), main neuroendocrine factor responsible for triggering plasticization.This neurohormone would be released axonal terminals reaching the abdominal tegument. Resilin and procuticle are involved. Hormones involved are Eclosion hormone and bursicon. Eclosion hormone -before ecdysis, Bursicon hormone-after eclosion

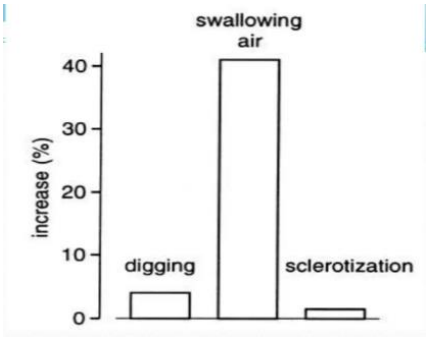


- **Plasticization in female grasshopper/locust:** The intersegmental membrane between abdominal segments 4 and 5, 5 and 6, 6 and 7 is made up of elastic cuticle (Pant and Ghai, 1981).

- **Plasticization in blood sucking bug:** The abdomen increases about four-fold and cuticle becomes thinner. Evoked by sensory inputs related to feeding. Serotonin hormone (5-HT), main neuroendocrine factor responsible for triggering plasticization. pH change in the cuticle from 7 to below 6. Water content increases from 26% to 31%. Decreasing hydrogen bonding. Plasticization is reversible and not permenant, and it becomes progressively less extensible with time (Melcon et al., 2005)
- **Cuticular plasticization in blood feeding mosquito:** Occurs as a result of the action of hormones or neurohormones. Female *Aedes trieseriatus*, feeding. "The treehole mosquito (*Aedes triseriatus*) transmits the virus that causes La Crosse encephalitis." Courtesy CDC.
- **Plasticization in tobacco horn worm:** The stretchability of the new, pharate cuticle may be temporarily increased to make it easier for the animal to escape from the rather stiff exuvium and facilitate expansion of the new cuticle after expansion. It is triggered by the release of eclosion hormone into the haemolymph. It is due to an intracuticular pH decrease in combination with increased hydration.

Extent to which a region on adorsal sclerite of a fly can be stretched

- During digging the cuticle is inextensible.



- Reaches the surface and swallows air to expand new cuticle this causes release of bursicon
- Cuticle now becomes sclerotized and inextensible

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11. POST HARVEST TECHNOLOGY

Enzymatic Spoilage in Fruits and Vegetables Processing

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Compounds are powerful protein impetuses for biochemical responses. The primary parts of proteins are L-α-amino acids except for glycine, which isn't chiral. The four degrees of protein structure are essential, optional, tertiary, and quaternary designs (Adams J B 1991). The essential construction is identified with the amino corrosive succession.

The amino of 1 - amino alkanoic corrosive is joined to the carboxyl of ensuing amino alkanoic corrosive by covalent holding, alluded to as a peptide linkage. The amino alkanoic corrosive sidechain bunches fluctuate regarding their properties like extremity, charge, and size. The polar amino alkanoic corrosive side gatherings will in general get on the outside of the protein where they collaborate with water, though the hydrophobic gatherings will in general be inside the inside piece of the protein. Optional construction (α-helix, β-pleated sheet, and turns) is indispensable for protein conformity. The right-gave α-helix is a standard course of action of the polypeptide spine by hydrogen holding between the carbonyl oxygen of one buildup (I) the nitrogenous proton of the other buildup (i¬4). The β-creased sheet is a creased structure made out of polypeptide chains connected together through bury amide hydrogen holding between nearby strands of the sheet. Tertiary construction alludes to the three-dimensional design of a collapsed protein.

Food sources can contain use carbs, (for example, mono and disaccharides), nitrogenous mixes, (for example, little peptides, amino acids, nucleosides, nucleotides, and urea) free unsaturated fats, and natural acids, (for example, lactic and malic acids). Microorganisms produce intracellular catalysts, (for example, endonucleases, muco peptidase, and proteinases) to use low sub-atomic weight food mixes by shipping into cells that cause perceptible food waste (Adams and Brown. 2007). The inventory of extra supplements from the hydrolysis of the macromolecules of food sources by extracellular proteins isn'tfundamental for the beginning of decay in numerous food sources. They either stay sure to the cell surface or are delivered to the climate. These catalysts hydrolyse enormous supplement atoms of food, (for example, polysaccharides, proteins, and lipids) to use into little particles. Microbial food decay from the digestion of low atomic weight supplements happens at the primary phase of microbial growth; waste from the breakdown of macromolecules by extracellular chemicals shows up late.

The demise microbial cells discharge the intracellular chemicals and these catalysts can cause food deterioration. In the event that the underlying number of microorganisms in nourishments is low, at that point decay by microbial catalysts would beneath. On the off chance that a bit of food is intensely, defiled with, countless starting microbial cells, at that point they may slaughter the microorganisms yet their compounds can't be inactivated. These excess catalysts can cause deterioration of the food. In thermally prepared nourishments, a few warmth stable catalysts of the microorganisms hold their movement after the cells are murdered. These compounds can separate the supplements to cause waste during the ensuing stockpiling of the food. Extracellular compounds causing waste in thermally treated nourishments are proteinases, lipases, and phospholipases of psychrotrophic microscopic organisms and amylases.

Enzyme catalyzed cycles may contribute quality weakening, especially in prepared nourishments (Yamauchi et al., 2004). For instance, for organic product squeeze, a steady sol is desired; The activity of gelatin methyl esterase (PME) is bothersome since demethylation of gelatin, catalyzed by PME. Hydrolases (cause hydrolytic response) and oxidoreductases (cause oxidation–decrease) are the significant compounds causing food waste. Hydrolytic proteins break compound bonds that includes water in the instrument. These proteins are regularly normally present in food sources or are created by microorganisms. Glucose goes through oxidation by burning-through oxygen from the air to D-¬gluconic corrosive. Lipoxygenases catalyze the oxidation of lipids within the sight of oxygen. It starts the oxidative rancidity of plant lipids containing high extent of unsaturated fats and causing offflavours.

Role of some enzymes in food spoilage (Bayindirli A, 2010)

Enzyme	**Food Spoilage**
Alkaline protease	Heat-stable alkaline proteases can cause gelation in milk products processed at UHT

Ascorbic acid oxidase	Oxidation of Ascorbic acids, and loss of vitamin C fruits, vegetables and juices
Cellulase	Loss of texture integrity and softening of plant foods, and releases glucose
Chlorophyllase	Removal of the phytol side chain from chlorophyll causes the degreening on plant foods (such as green vegetables)
Lipase	Hydrolysis milk fat to release short-chain fatty acids and cause rancidity and off-flavours (such as in milk and meat)
Lipoxygenase	Formation of hydro peroxides can cause bleaching of pigments, offensive flavour causes texture change, destruction of vitamin A, and loss of nutrients (such as on legume seeds)
Pectinases	Destruction of pectic substance and this results in loss of texture integrity and softening (such as in vegetables and fruits).
Peroxidase	Decomposition of hydrogen peroxides with generation of free radicals causes browning, off-flavour, and so on (such as in vegetables and fruits).
Phospholipase	Denaturation of muscle proteins and texture deterioration (such as in fish)
Polyphenoloxidase	Browning, off-flavour, and vitamin loss (such as in fruits, vegetables, and shellfish)
Proteinases	Decomposition of proteins with formation of amino acid and small peptides to give bitter flavour, reduction of shelf life, over tenderness (such as in eggs, fish, and flour)
Thiaminase	Decomposition of thiamine (such as in shellfish and meat)
Trimethylamine oxide demethylase	Releases formaldehyde in frozen fish contributing to protein aggregation and texture deterioration

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12. PLANT PATHOLOGY

Entomopathogenic Nematode: A Brief Introduction

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Entomopathogenic nematodes (EPN) are soft bodied, non-segmented roundworms that are usually obligate parasite or sometimes facultative parasites of insects. They occur naturally in soil and locate their host in response to CO_2 , vibration and some other chemicals cues (kaya and Gaugler 1993). The EPN families belong to *Heterorhabditidae*and *Steinernematidae* have been found very effective in biological management of insect pests (Grewal et al. 2005).The juvenile stage of EPN penetrate the host insect frequently via mouth, spiracles, anus or sometimes intersegmental membranes of the cuticle and then enter into hemocoel (Bedding and Molyneux 1982), where they release cells of

their symbiotic bacteria from their intestines into hemocoel. The bacteria multiply in the insect hemolymph and infected host usually dies within 24-48 hours. After the death of host, nematode continue to feed on the host ((kaya and Gaugler 1993). The insect cadaver represent red colour if they are killed by heterorhabditids and become brown or tan if killed by steinernematids (kaya and Gaugler 1993). Heterorhabditis and Steinernema have mutual association with bacteria of genera *Photorhabdus* and *Xenorhabdus* respectively (Ferreira and Malan 2014). Reproduction process differ in both families The infective juveniles of heterorhabditid nematodes become hermaphroditic adults but individuals of the next generations are produced by males and females (Grewal et al. 2005). EPNs use two search strategies i.e. Ambushers and Cruisers (Grewal et al. 1994a). Ambushers such as *Steinernemacarpocapsae* have an energy conserving approach and lie-in-wait to attack mobile insects in upper soil. Cruisers such as *Steinernemaglaseri* and *Heterorhabditis bacteriophora* are highly active and moving significant distances using volatile cues and other methods to find their host underground. Some nematodes such as *Steinernemafeltiae* and *Steinernemariobrave* use combination of ambush and cruiser type strategy to find their host.

Table 1.Commercial use of EPN Steinernema and Heteorhabditis as bioinsecticides.

EPN species	Targeted major pests
Steinernemaglaseri	White grubs (scarabs, especially Japanese beetle, *Popillia* sp.), banana root borers
Steinernemakraussei	Black vine weevil, *Otiorhynchussulcatu*
Steinernemacarpocapsae	Turfgrass pests-billbugs, cutworms, armyworms, sod webworms, chinch bugs, crane flies. Orchard, ornamental and vegetable pests - banana moths, codling moths, cranberry girdlers, dogwood borers and other clearwing borer species, black vine weevils, peachtree borers, shore flies (*Scatella* spp.)
Steinernemafeltiae	Fungus gnats (*Bradysia* spp.), shore flies, western flower thrips, leafminers
Steinernemascapterisci	Mole crickets (*Scapteriscus* spp.)
Steinernemariobrave	Citrus root weevils (*Diaprepes* spp.), mole crickets
Heterorhabditisbacteriophora	White grubs (scarabs), cutworms, black vine weevils, flea beetles, corn root worms, citrus root weevils
Heterorhabditismegidis	Weevils
Heterorhabditisindica	Fungus gnats, root mealybugs, grubs
Heterorhabditismarelatus	White grubs (scarabs), cutworms, black vine weevils
Heterorhabditiszealandica	Scarab grubs

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