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1. ENTOMOLOGY

Role of Vitamins in Insect Nutrition

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Vitamins are organic compounds required in trace amounts for sustained growth. Vitamins are classified as either water soluble or lipid soluble. Water-soluble vitamins have a far shorter half-life in insect tissues than lipid-soluble vitamins, which tend to accumulate in lipid stores. The chief water-soluble vitamins required by insects are vitamin C (ascorbic acid) and the B vitamins. The response to dietary deficiency of these vitamins appears to be much less specific in insects than mammals. For example, mammals exhibit well-defined symptoms, such as beriberi (vitamin B1 deficiency) and scurvy (vitamin C deficiency), while insects generally display non-specific growth defects in response to a shortfall in the dietary supply of any water-soluble vitamins (Chapman, 1998). Our understanding of vitamin function in insects is largely extrapolated from vertebrate research. Vitamin C acts as an antioxidant and, presumably as in vertebrates, promotes the synthesis of collagen and the extracellular matrix in insects. The B vitamins function as cofactors in various metabolic pathways, including: decarboxylations (vitamin B1, thiamine); flavoproteins (vitamin B2, riboflavin) and cytochromes (vitamin B3, niacin) in ATP production; acyl group transfer reactions (vitamin B5, pantothenate); amino acid metabolism (vitamin B6, biotin); and one-carbon transfer reactions (vitamin B9, folic acid). Additional water-soluble vitamins required in very small amounts by some insects include: choline, carnitine, cyanocobalamine (also known as vitamin B12) and lipoic acid. Among the four lipid-soluble vitamins of mammals, insects have a requirement for the vitamin A complex (b-carotene and related carotenoids) and vitamin E (tocopherols), but apparently not for vitamin D (calciferols) or vitamin K (phylloquinone). Vitamin A is required as a functional component of visual pigments. The amounts required by some insects are tiny: for example, in one classic study, the dietary requirement of the housefly, Musca domestica, was revealed only in the 15th generation on vitamin A-free diet (Chapman, 1998). By contrast, Schistocerca reared on a carotene-free diet display reduced growth and delayed development in a single generation. Vitamin E is important for reproduction of insects, including spermatogenesis in the house cricket, *Acheta domesticus,* and egg maturation in the beetle *Cryptolaemus montrousieri.*

Studies of insect vitamin requirements especially are subject to ambiguity if axenic conditions are not maintained. In some early work with stored product insects reared on very dry diets seemed to avoid the interfering effect of microorganisms, which can synthesize many of the vitamins that insects then utilize. These studies showed that insects need thiamine, riboflavin, pyridoxine, niacinamide, pantothenic acid, biotin, folic acid, and choline. Carnitine, also called vitamin BT, is a requirement for *Tenebrio molitor* (Nation, 2008) and *Tribolium obscurus, T. confusum*, and *T. castaneum.* Different strains of these insects show variable requirements. One of the critical roles for carnitine is as a participant in the passage of fatty acids across mitochondrial membranes in insects and vertebrates.

Houseflies and blowflies are able to use β-methylcholine and γ-butyrobetaine to reduce the need for choline. When these compounds are fed to flies, the phospholipids of most tissues contain β-methylcholine, but acetylcholine in central nervous system tissue is not substituted. *T. molitor* larvae also incorporate β-methylcholine into body phospholipids, which spares the choline requirement.

There is demonstrated requirement for water-soluble vitamins in the nutrition of a few insects. Ascorbic acid is required for normal growth and development of some insects and seems particularly needed by phytophagous insects (Vanderzant and Richardson, 1963;

Chippendale and Beck, 1964). Boll weevils, *Anthonomus grandis*, grown under aseptic conditions require inositol for normal growth and development, as do *Blattella germanica* and *P. americana*, German and American cockroaches, respectively. Inositol often seems to improve the growth of many insects, but it has not been demonstrated to be essential in most insects.

Carotene and/or vitamin A are required by insects for normal pigmentation and eye function. *Schistocerca gregaria* needs β-carotene for normal body coloration. Vitamin A is required by houseflies, *Musca domestica*, and tobacco hornworms, *M. sexta*, for normal structure of the eye. Because so little carotene or vitamin A is required (and/or small amounts were contaminating the "purified" diet), houseflies had to be reared for 15 generations on a diet lacking carotenoids and vitamin A to demonstrate conclusively that the vitamin is needed. The 12th and 13th generations had about the same sensitivity in the compound eyes, measured by electroretinograms in response to 340 and 500 nm light, as the first generation. The response from eyes of deficient flies was 2 log units (100×) less sensitive than from eyes of normal flies (Goldsmith et al., 1964; Sang, 1956). There were changes in rhabdom structure, loss of basement membrane in some places, and degeneration of nervous tissue in the eyes of *M. sexta* reared for several generations on a diet deficient in vitamin A or β-carotene. Moths from the deficient diet showed abnormal orientation to light, and the eyes failed to adapt to the dark (Cohen, 2003). Vitamin A accelerates growth of the fly *A. affinis* and the silkworm Bombyx mori, but it is not clear that it has a metabolic function in growth apart from its visual function.

Vitamin B12 stimulates the growth of some insects, but a clear-cut requirement for growth has not been shown. Possibly, the small amount that may satisfy an insect requirement can occur as a contaminant of other nutrients or be provided by symbionts. Omission of the vitamin from the diet of B. germanica results in nonviable eggs, so possibly, it plays a biochemical role in at least some insects.

Vitamin E is necessary to a beetle, *Cryptolaemus montrouzieri*, in order for adult females to mature and oviposit eggs. The vitamin also is required for spermatogenesis in male house crickets, *A. domesticus*. The parasitoid *A. affinis* needs vitamin E in the larval diet for adult females to produce viable offspring. The vitamin also stimulates growth and development of larvae. There is no evidence that vitamin D is required by insects. Vitamin K in its several forms has been tested on some insects, usually without any observable effects, but it may have some positive benefit (mechanism unknown) on crickets and may act as a phagostimulant for adult worker honeybees (Dadd, 1985).

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2. ENTOMOLOGY

Persistence and Pollution Due to Pesticide Use

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Introduction

In recent years people have been exposed to several types of substances with broad spectrum due to rapidly evolving technology. One of these chemical substance groups are pesticides. Pesticides have been an essential part of agriculture to protect crops and livestock from pest infestation and yield reduction for many decades. Despite their usefulness, pesticides could pose potential risks to food safety, the environment, and all living things. Concern about the environmental impact of repeated pesticide use has prompted research into the environmental fate of these agents, which can emigrate from treated field to air, other land, and water bodies.

What is a Pesticide

Pesticides are synthetic chemical compounds that are used in the agricultural sector to get rid of pests such as insects, fungi, rodents, and unwanted weeds. Term pesticide is often treated as synonymous with plant protection product. Term pesticide includes all of the following, herbicide, insecticide, insect growth regulator, nematicide, termiticide, molluscicide, piscicide, avicide, rodenticide, bactericide, predacide, insect repellent, animal repellent, antimicrobial, fungicide, disinfectant (antimicrobial), sanitizer.

Disadvantages

The reduction of these beneficial organisms can result in changes in the natural biological balances. Residues in food for humans and feed for livestock can be a consequence of direct application of a chemical to the food source, by the presence of pollutants in the environment or by transfer and biomagnification of the chemical along a food chain. Resistance to the pesticide used can develop in target pests due to overuse and incorrect use of the chemical. Poisoning hazards and other health effects to operators can occur through excessive exposure if safe handling procedures are not followed and protective clothing. Non-target organisms, including predators and parasites of pests, can also be affected by chemical application. Ground water contamination by leached chemicals can occur in high use areas if persistent products are used.

What happen to chemicals in the enviroment after application

When pesticides are applied the goal is that they will remain in the target area long enough to control a specific pest and then degrade into harmless compounds without contaminating the environment. Once applied, many pesticides are mobile in the environment (air, soil, water). The movement can be beneficial (moving pesticide to target area, such as roots) but can also reduce the effect on the target pest and injure nontarget plants and animals. It have ability to contaminate every part of the environment (Gavrilescu, 2005).

Persistence

Ability of a pesticide to remain present and active for a long time. It may also lead to illegal residues on rotational crops. Provides for long term pest control, but may harm sensitive plants and animals. Pesticide persistence is often expressed in terms of Half-life. Half life is the length of the time required for one-half of the original quantity to break down. For example, if a pesticide has a half-life of 15 days, 50 percent of the pesticide applied will still be present 15 days after application and half of that amount (25 percent of the original) will be present after 30 days. Persistence in the soil may vary greatly with respect to degradation which is influenced by number of factors. Pesticides can be divided into three categories based on half-lives:

1. Non-persistent pesticides: <30 days
2. Moderately persistent pesticides: 30 to 100 days
3. Persistent pesticides: >100 days

Ultimately the degradation products are water, carbon dioxide and minerals. However, the intermediate degradation products of some pesticides are of concern for health or environmental reasons. Persistence is affected by photodegredation, chemical degredation and microbial degredation. All three processes may participate in the breakdown of a single pesticide. The rate of degradation depends on pesticide chemistry, as well as on environmental conditions. Distribution between foliage and soil, as well as temperature, soil and water pH, microbial activity, and other soil characteristics may affect pesticide persistence.

Pesticides disappears from soil in 3 steps:

1. Acclimation phase: Prior to the degradation, a period is noted in which no disappearance on the compound is evident. Sometimes it is adaptation or lag period, which is the length of time between entry of pesticides into soil and evidence of its detectable loss.
2. Dissipation Phase: No change in concentration is noted but then the disappearance becomes evident and the rate of loss often becomes quickly.
3. Persistence Phase: Which is longer, and is expressed in units of time- hours, days, weeks, months and even years.

Fate of Pesticides in the Environment- Pollution

Pesticides effect the environment by point-source pollution and nonpoint- source pollution (Gavrilescu, 2005).

The former is the contamination that comes from a specific and identifiable place, including pesticide spills, wash water from cleanup sites, leaks from storage sites, and improper disposal of pesticides and their containers.

The latter is the contamination that comes from a wide area, including the drift of pesticides through the air, pesticide run off into waterways, pesticide movement into ground water (Toth and Buhler, 2009). Over 2 billion kilograms of pesticide is applied annually to protect crops all around the world. Only 0.1% of those pesticides carries out their function and target pests effectively. The rest of them just goes to waste and endangers the environment.

Agriculture pollution: Contamination of soil, air and water environments due to farming activities. The primary agricultural pollutants are: nutrients (nitrogen and phosphorus), Pesticides, sediments, salts, wastes

Soil pollution: The use of pesticides decreases the general biodiversity in the soil, also affect to the soil micro-organisms & decrease the soil fertility, effect the growth of the plants, residual effect of the pesticide in the soil, enter the food chain & bio magnification, alters the pH, decrease soil quality. may also be carried to water by eroding soil (Das and Das, 2004).

Water Pollution: Eutrophication- Change in quality and composition of aquatic ecosystems by accumulation of excessive chemicals in water bodies, application of herbicides to bodies of water can cause fish kills, water become unfit for drinking (NRCCLRSWCP, 1993). altering the physical characteristics of water bodies, runoff of into streams, lakes, and other surface waters can increase the growth of algae. At least 143 pesticides and 21 of their transformation products have been found in ground water, from every major chemical class, 90% of water wells sampled by US geological survey showed evidence of pesticides pollution. Pesticides most frequently detected in ground water is the carbamate insecticide aldicarb: ground water contamination problems, sampled for extensively (Toth and Buhler, 2009).

Air Pollution: Entry of pesticides into the atmosphere, application drift, post-application vapour losses, wind-erosion of pesticide-treated soil, pesticides are a major contributor to air pollution, pesticides may also adhere to dust particles and travel with them, chemicals from aerosol sprays may drift far away once they are suspended in air as minute particles, humans and animals breathing in that air are at risk of multiple conditions. Pesticides frequently detected in the atmosphere are, (I) organochlorine insecticides: resistant to environmental degradation, (II) organophosphate insecticides: not long-lived in environment.

Measures: To minimize this air pollution farmers can establish a buffer zone around their crop fields. plants such as evergreen trees to serve as windbreaks and absorb the pesticides, It prevent drift in to other areas, such windbreaks are legally required in the Netherlands.

Pesticide effect on plants

specially pentachlorophenol interfere with legume- rhizobium chemical, reduction of this symbiotic chemical results in reduced nitrogen fixation, pesticides can kill bees and decline the pollinators.

Pesticide effect on animals

Pesticides can eliminate some animals' essential food sources, residues can travel up the food chain, pesticides have harmful effects on growth and reproduction on earthworms, pesticide exposure can be linked to cancer, endocrine disruption, reproductive effects, neurotoxicity, kidney and liver damage, birth defects and developmental changes in a wide range of species

Pesticide effect on Birds

The US estimates that 72 million birds are killed by pesticides in the United States each year, DDT-induced egg shell thinning has especially affected European and North American bird populations, paraquat, when sprayed onto bird eggs, causes growth abnormalities in embryos and reduces the number of chicks that hatch successfully

Effects of Pesticides on Humans (Farmers)

Pesticides are the leading cause of serious health problems in farmers. The health implication can vary from an acute allergic reaction to a chronic disease that gradually deteriorates the farmer’s health. Pesticides can cause long-term and short-term health problems. short-term health effects include, irritations, rashes, vomiting, nausea, headaches, seizures, dyspnea, loss of consciousness (rare). Long-term health effects of pesticides include, weakened immune systems, anxiety and depression, neurological conditions, hormonal imbalances, cancers.

Residues of Pesticides

Residues in human blood: Organochloro insecticides found in samples of blood serum in rural areas of ahmedabad showed an average of 200.3 ppb, among all HCH and DDT (Dichloro Diphenyl Trichloroethane) were chief contaminants (Seiber, 2002)

Residues in human milk: – Potential risk to infants – Toxicological implication cannot be assessed precisely – Hexachlorobenzenes a fungicide is found in human milk and fat

The World Health Organization estimates that there are 3 million cases of pesticide poisoning each year and up to 220,000 deaths, primarily in developing countries.

The exact number may actually be higher, especially because most farmers do not seek medical help and may die without identification of the underlying cause.

Solutions to Pesticide Exposure

Awareness must be raised among farmers about effects of pesticides to their health and environment, we need to encourage them to use fewer pesticides if they can’t completely abandon it immediately, various health organizations must work in coherence with governments to educate farmers and treat them with pesticide related health issues.

Ways to minimize environmental impact of pesticide: Practicing Integrated Pest Management (IPM), only using pesticides that are labeled for the intended crop and pest, measuring accurately, maintaining application equipment and calibrating accurately, mixing and loading carefully, preventing backsiphoning and spills, considering the impact of weather/irrigation, storing pesticides safely and securely, disposing of wastes safely, leaving buffer zones around sensitive areas, reducing off-target drift (Reichenberger *et al.* 2007, Cessna *et al.* 2005)

Alternatives

Use of biological pest controls (such as pheromones and microbial pesticides), genetic engineering, and methods of interfering with insect breeding, application of composted yard waste, cultivation practices include polyculture (growing multiple types of plants), crop rotation, use of trap crops, natural predators or parasites of the pests, biological pesticides based on entomopathogenic fungi, bacteria and viruses cause disease in the pest species can also be used, interfering with insects' reproduction can be accomplished by sterilizing males, soil steaming kills pest and increases soil health, In India, traditional pest control methods include using Panchakavya, integrated pest management (IPM)

Conclusion

In modern agriculture use of pesticides is a must, but proper and efficient use has to be done , To save current and also future generation, ecology; judicious use of chemicals is recommended, Alternative strategies- Bio-pesticides, IPM

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3. SOIL SCIENCE

Management Strategies to Improve Nitrogen Use Efficiency

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Introduction

Nitrogen is a fundamental element for plant growth and plays a pivotal role in agricultural productivity. As a key component of chlorophyll, amino acids, and proteins, nitrogen is essential for various physiological processes in plants. However, inefficient nitrogen use in agriculture can have detrimental effects on the environment, human health, and economic resources. Moreover, the ever-changing characteristics of nitrogen (N) and its tendency to be lost from soil-plant systems present a distinctive and complex setting, posing challenges for effective management. Nitrogen Use Efficiency is the amount of plant yield in terms of either grain or biomass produced per unit of applied nitrogen. Leguminous crops have a high NUE because they gather and store nitrogen in their bodies rather than release it into the atmosphere (Kumar *et al.*, 2016).

Factors Influencing Nitrogen Use Efficiency:

- **Texture and Structure:** Soil texture and structure influence nitrogen retention and availability. Sandy soils may have lower water and nutrient-holding capacities, leading to higher nitrogen leaching. In contrast, clayey soils may retain nitrogen but may pose challenges in terms of nutrient accessibility to plants.
- **Temperature and Moisture:** Climate conditions, including temperature and moisture levels, significantly impact microbial activity in the soil, affecting nitrogen transformations. Warm and moist conditions can enhance microbial activity, promoting nitrogen mineralization and availability to plants.
- **Application Timing:** The timing of nitrogen application is critical. Matching nitrogen supply with crop demand at different growth stages helps optimize uptake and utilization. Applying nitrogen too early or too late can result in inefficient use and potential losses to the environment.
- **Split Applications:** Splitting nitrogen applications into multiple doses throughout the growing season can improve NUE by minimizing losses through leaching or volatilization.
- **Genetic Traits:** Crop varieties vary in their ability to efficiently utilize nitrogen. Breeding for nitrogen-efficient traits, such as improved root architecture, nitrogen uptake efficiency, and nitrogen utilization efficiency, can contribute to enhanced NUE.
- **Crop Rotation and Diversity:** Rotating crops and incorporating nitrogen-fixing legumes into the cropping system can positively influence NUE by promoting biological nitrogen fixation and improving soil nitrogen availability for subsequent crops.
- **Tillage and Crop Residue Management:** Tillage practices can impact nitrogen mineralization and losses. Reduced tillage or conservation tillage can help maintain soil organic matter and microbial activity, contributing to improved NUE.
- **Cover Crops:** Integrating cover crops into rotations can enhance nitrogen retention, reduce leaching, and improve soil structure, ultimately benefiting NUE in subsequent crops.
- **Irrigation Practices:** Efficient water management is crucial for NUE. Proper irrigation practices help maintain soil moisture levels, influencing microbial activity and nutrient availability.
- **Interactions with Other Nutrients:** The availability of other essential nutrients, such as phosphorus and potassium, can influence nitrogen uptake and utilization. Balanced nutrient management is essential for optimizing overall plant nutrition.

Agronomic Practices for Improving Nitrogen Use Efficiency

- **Crop Genetic Selection:** Choose crop varieties that exhibit traits associated with nitrogen-use efficiency. Some varieties may have enhanced nitrogen uptake or utilization capabilities, contributing to improved NUE.
- **Precision Nitrogen Application:** Use precision agriculture tools, such as VRT, to tailor nitrogen application rates based on spatial variability in soil characteristics and crop needs. This

helps optimize nitrogen use across different areas of a field.

- **Optimized Timing of Nitrogen Application:** To maximize the efficiency and effectiveness of nitrogen fertilizers, it is important to consider the timing of their application (Wang & Li, 2019). Divide the total nitrogen application into multiple doses throughout the growing season to match crop demand. This minimizes the risk of nitrogen losses due to leaching or volatilization and ensures that nitrogen is available when the crop needs it most.
- **Use of Controlled-Release Fertilizers:** Controlled-release fertilizers release nitrogen gradually, providing a sustained supply to crops over an extended period. Additionally, the use of controlled-release fertilizers can reduce the risk of nutrient imbalances and deficiencies, as they provide a consistent supply of nutrients throughout the (Shoji *et al.*, 2001)
- **Nitrogen Fixing Crops:** Leguminous crops have the ability to form symbiotic relationships with nitrogen-fixing bacteria, contributing to soil nitrogen availability. Include legumes like soybeans, peas, or clover in rotations.
- **Use of Nitrification Inhibitors:** Nitrification inhibitors slow down the conversion of ammonium to nitrate in the soil, reducing the risk of nitrogen leaching. Incorporating these inhibitors into fertilizer applications can enhance nitrogen retention.
- **Conservation Tillage:** Adopt conservation tillage methods to preserve soil structure and organic matter. Reduced tillage minimizes nitrogen losses through volatilization and erosion, promoting improved NUE.

Conclusions

The importance of understanding NUE cannot be overstated, considering its impact on crop productivity and environmental sustainability. Balancing the agricultural demand for nitrogen with environmental concerns requires precision and adaptability. Agronomic practices, such as precision application, cover cropping, and conservation tillage, emerge as effective strategies for improving NUE. The integration of technological innovations, including remote sensing and genetic selection, holds promise for sustainable nitrogen management.

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4. ENTOMOLOGY

Insights into Fungal Entomopathogens

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Introduction

Insect pests pose a significant threat to agricultural productivity worldwide, causing substantial economic losses by damaging plant parts and reducing crop yields. Traditional methods of pests control, such as chemical pesticides, often come with environmental and health concerns. As sustainable agriculture gains traction, there is growing interest in utilizing biocontrol agents, such as fungi, to manage pest population. Fungi are heterotrophic, eukaryotic microorganisms having worldwide distribution. The oldest known fungal entomopathogens date back to the Early Cretaceous period. From then several fungal species with potential for insect pest biocontrol were reported. One such fungus, *Beauveria bassiana*, is known for its ability to infect various insect species, causing white muscardine disease. It exhibits high host specificity, targeting insects like sand flies, termites, tsetse flies, whiteflies, colorado potato beetle and codling moth. Similarly, *Verticillium lecanii* is effective against pests like whiteflies and aphids. *Metarhizium anisopliae* and *Nomuraea rileyi* are also explored for their potential as insect biocontrol agents, targeting pests like teak skeletonizer and various moth species. Fungal entomopathogens produce various secondary metabolites, some of which have medicinal properties (e.g., penicillin) or are toxic (e.g., mycotoxins). *Beauveria* spp. produce cyclodepsipeptides such as beauvericin, beauverolides, and bassianolides. *Metarhizium* spp. produce cytochalasins, destruxins, cytochalasin, myroridins, and helvolic acid. These compounds have insecticidal properties and may contribute to the pathogenicity of the fungus.

Infection Process

- **Attachment to the Cuticle**: Fungal entomopathogens need to penetrate the insect cuticle, which is composed of chitin and proteins. The attachment of fungal spores to the cuticle can vary depending on the surface properties of the spores and the cuticle.
- **Spore Germination**: After attachment to the cuticle, spores germinate, forming a germ tube and potentially an appressorium. Some fungal species produce mucilage or adhesive droplets to aid in attachment and germination.
- **Cuticle Penetration**: To obtain nutrients and colonize the host, the fungus must breach the insect cuticle. This can occur through mechanical pressure and the production of cuticle-degrading enzymes like proteases, chitinases, and lipases.
- **Invasion of the Haemocoel**: Different fungal species employ different strategies for killing the host. Some fungi grow profusely, consuming host nutrients and physically damaging tissues, while others rely on the production of toxins.
- **Insect Responses to Infection**: Insects have evolved various mechanisms to defend against fungal pathogens, including grooming behaviours and immune responses. Social insects like ants and termites exhibit mutual grooming to remove fungal spores, while non-social insects may show increased resistance when reared in crowded conditions.

Environmental Factors Influencing Stability

- **Ultraviolet Light**: UV radiation can damage fungal conidia by affecting nucleic acids, proteins, lipids, and membranes. Conidia pigmentation influences their susceptibility to UV radiation, with more pigmented conidia being more tolerant. Artificial methods like sunscreens or natural pigments in formulations can protect conidia from UV radiation.

- **Temperature**: Some entomopathogens can remain infective at low temperatures, enabling infection even when host insects are inactive. Most fungal entomopathogens do not grow at human body temperature, which is a positive aspect for risk assessment. Temperature might have a stronger negative effect on fungal entomopathogen infection of insects close to the soil surface due to higher temperatures recorded there.
- **Humidity**: Humidity levels affect conidial germination, fungal growth, and sporulation on insect cadavers. High humidity is often needed for successful infection.

Bioassay to Field Application

Pathogenicity (ability to cause disease) and virulence (degree of pathogenicity) are crucial factors when assessing the effectiveness of fungal entomopathogens. Laboratory bioassays are often used to evaluate virulence by determining the LC50, LD50, and LT50. Bioassays conducted under optimal laboratory conditions may not fully represent the performance of fungal isolates in the field. Despite this limitation, laboratory bioassays are still valuable for selecting isolates for further field trials and commercialization. Establishing a single-spore stock culture is crucial to maintain genetic uniformity and avoid contamination, ensuring consistent performance in bioassays and field applications. Production of fungal entomopathogens involves mass production of infective spore forms such as conidia or blastospores. Solid-substrate fermentation and liquid culture are common methods for mass production, each with its advantages and challenges. Formulation is another critical aspect, ensuring the stability of the organism during storage and effective delivery in the field. Liquid formulations and solid formulations such as wettable powders, dusts, granules, and baits are commonly used, each with its specific advantages depending on the application method and target insect species.

Important Case Studies

- The accidental introduction of gypsy moths in the late 1860s led to significant defoliation of hardwood forests in the USA. In an attempt to control the gypsy moth population, the fungal entomopathogen, *Entomophaga maimaiga* was introduced from Japan. Although initial attempts were unsuccessful, subsequent introductions in 1991 and 1992 led to its establishment and resulted in significant reductions in gypsy moth populations.
- The LUBILOSA project, initiated in 1989, aimed to control swarms of locusts and grasshoppers in Africa using the fungal entomopathogen, *Metarhizium acridum*. This project resulted in the development and commercialization of a fungal strain marketed as Green Muscle, which was applied as a ULV spray to treat infested areas.
- In Brazil, *Metarhizium anisopliae* has been used to control spittlebugs in sugarcane and pastures. Approximately 1.5 million hectares of land were treated with *M. anisopliae* in 2011, highlighting the widespread adoption of fungal biocontrol agents in agriculture.

Conclusion

Despite significant progress in understanding fungal entomopathogens, there are still areas in need of exploration. Research on the ecology of fungal entomopathogens, including their interactions with insect hosts and the environment, is essential. Additionally, studying the impact of climate change on fungal entomopathogens and exploring novel delivery methods are crucial for their successful application in pest management. Furthermore, sequencing the genomes of various fungal entomopathogens can provide valuable insights into their genetic makeup, virulence factors, and host specificity.

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5. AGRICULTURE

Secondary Agriculture; A sunrise Sector of Indian Economy

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Introduction

"Secondary agriculture" typically refers to activities that are undertaken after the primary agricultural production stage. Primary agriculture involves the cultivation of crops and the raising of livestock, while secondary agriculture involves the processing, marketing, and value addition to the raw agricultural products.

Secondary agriculture takes the output of the primary sector to produce finished goods suitable for other business and domestic usage. Mainly, Fruits, vegetables and their value-added products lead to income diversification and livelihood improvement of the farmers. As India is going through economic and social transformation an agriculture-based economy to product and service-based economy and also knowledge-based economy. In the present context, the secondary agriculture is gaining importance to ensure doubling of farmers income, sustainable use of natural resources, small farm viability and profitability, food and nutrition security and adoption to the changing climate.

Secondary agriculture activities include:

1. **Processing and Manufacturing:** This involves converting raw agricultural products into processed goods. For example, milling wheat into flour, processing fruits into jams or juices, and converting milk into dairy products.
2. **Agro-Processing:** This term is often used interchangeably with secondary agriculture. Agro-processing involves adding value to agricultural products through various processes such as drying, canning, and packaging.
3. **Food and Beverage Industry:** Secondary agriculture encompasses the food and beverage industry, which involves the production of a wide range of consumable goods derived from agricultural products.
4. **Textile Industry:** Agriculture also contributes to the textile industry through the cultivation of crops like cotton, and secondary agriculture involves processing these raw materials into textiles and clothing.
5. **Bioenergy Production:** Converting agricultural products, such as crops or waste materials, into biofuels or other forms of renewable energy falls under secondary agriculture.
6. **Supply Chain and Distribution:** This aspect involves the logistics, transportation, and distribution of agricultural products from the farm to the consumer. Efficient supply chains are crucial for ensuring that agricultural products reach their intended markets.
7. **Marketing and Retail:** Promoting and selling agricultural products to consumers through various channels, including supermarkets, farmers' markets, and online platforms.

Need of secondary agriculture in India

Secondary agriculture plays a vital role in adding value to raw agricultural products and ensuring that they reach consumers in a usable and marketable form. It involves a diverse range of activities that contribute to the overall

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agricultural value chain. It is of significant importance for several reasons, contributing to the overall development and sustainability of the agricultural sector and the economy as a whole. Here are some key reasons highlighting the importance of secondary agriculture:

1. **Value Addition:** Secondary agriculture adds value to raw agricultural products through processing, manufacturing, and other value-added activities. This enhances the economic value of agricultural goods and increases the potential income for farmers and other stakeholders in the agricultural value chain.
2. **Diversification of Income Sources:** By engaging in secondary agriculture, farmers and entrepreneurs can diversify their income sources. Instead of relying solely on the sale of raw produce, they can participate in various processing and manufacturing activities, which can provide additional streams of revenue.
3. **Employment Generation:** Secondary agriculture activities, such as agro-processing, manufacturing, and distribution, create job opportunities along the entire value chain. This helps reduce unemployment and underemployment in rural and urban areas, contributing to overall economic development.
4. **Rural Development:** The development of secondary agriculture can play a crucial role in rural development. It encourages the establishment of processing units and industries in rural areas, leading to improved infrastructure, better living standards, and overall economic growth in these regions.
5. **Food Security:** Secondary agriculture supports the availability of processed and preserved food products, contributing to food security. Food processing helps in reducing post-harvest losses and ensures a more stable and consistent food supply throughout the year.
6. **International Trade and Export:** Processed and value-added agricultural products are often more suitable for export, contributing to international trade. This can lead to increased foreign exchange earnings for a country, helping to balance trade deficits.
7. **Technological Innovation:** Secondary agriculture involves the application of technology and innovation in processing and manufacturing. This not only improves efficiency but also stimulates research and development in agriculture-related technologies.
8. **Waste Reduction and Sustainability:** Secondary agriculture often involves utilizing by-products and waste from primary agriculture. This reduces waste, promotes sustainability, and can contribute to environmentally friendly practices through recycling and repurposing.
9. **Market Development:** Developing a robust secondary agriculture sector helps in creating and expanding markets for agricultural products. Processed and value-added goods often have a broader appeal and can reach a wider consumer base.
10. **Economic Growth:** The growth of secondary agriculture contributes to overall economic growth by increasing the GDP of a country. It enhances the productivity and profitability of the entire agricultural sector, positively impacting the economy as a whole.

In India, the strengthening and expansion of secondary agriculture and its linkage to primary sector is very crucial. This can be speed up by encouraging public-private partnership and enabling rural industrialisation to link farm and non-farm activities.

6. ENTOMOLOGY

Kalmegh (*Andrographis paniculata*): The Immunity Powerhouse of Nature

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Kalmegh, or *Andrographis paniculata*, is a yearly herb from India and Sri Lanka. It's been used in Ayurvedic medicine for a long time and is often called Green Chiretta or Hara chiretta. This herb is known for its many healing properties that can improve health and well-being. It can boost the immune system and help the body fight off infections, especially those in the upper respiratory tract. Kalmegh is a versatile herb that's mentioned in ancient Ayurvedic texts for its anti-inflammatory and immune-boosting effects. It's also used in Siddha, Unani, Homeopathic, and Chinese medicine. Kalmegh can help with common colds, fevers, digestion, detoxification, and blood purification.

Habitat: Kalmegh is a plant that grows widely in Southeast Asia, including India, Sri Lanka, Pakistan, and Indonesia. It's also cultivated in China, Thailand, the East and West Indies, and Mauritius. The plant grows naturally in various environments like pine forests, evergreen areas, deciduous forests, along roads, and in villages. In India, it's grown during the rainy phase of the summer season. The plant thrives in soil rich in organic matter, making it suitable for commercial cultivation. About 400 grams of seeds are enough for one hectare, and the plants are spaced 30cm by 15cm apart. The plants are generally free from major pests and diseases. When the plants reach the flowering stage, about 90 to 120 days after sowing, they are cut at the base, leaving a 10 to 15cm stem for regeneration. A final harvest is done about 50 to 60 days after the first harvest. In India, the yield varies between 2000 to 2500 kilograms of dry herb per hectare.

Plant Parts used: The parts of the plant that grow above the ground, like the leaves and stems, are used for their medicinal properties. They are used to extract active compounds that have health benefits. Although it's not common, sometimes the roots of the plant are also used for this purpose.

Table: 1 Properties of Kalmegh (*Andrographis paniculata*)

1	Analgesic (pain killer) reduces swelling and cuts down exudation from capillaries; anti-inflammatory action probably mediated, in part, by adrenal function)
2	Antibacterial (fights bacterial activity; although *Andrographis* appears to have weak direct antibacterial action, it has remarkably beneficial effect in reducing diarrhoea and symptoms arising from bacterial infections.)
3	Antiperiodic (counteracts periodic/intermittent diseases, such as malaria)
4	Antipyretic (fever reducer - both in humans and animals, caused by multiple infections or by toxins)
5	Antithrombotic (blood clot preventative)
6	Antiviral (inhibits viral activity)
7	Cancerolytic (fights and kills cancer cells)
8	Cardioprotective (protects heart muscles)
9	Choleretic (alters the properties and flow of bile)
10	Depurative (cleans and purifies the system, particularly the blood)
11	Digestive (promotes digestion)
12	Expectorant (promotes mucus discharge from the respiratory system)
13	Hepatoprotective (protects the liver and gall bladder)
14	Hypoglycemic (blood sugar reducer)
15	Immune Enhancement (increases white cell phagocytosis, inhibits HIV-1 replication, and improves CD4 + and T lymphocyte counts)
16	Laxative (aids bowel elimination)
17	Sedative (relaxing herb, though not with the same effect as the accepted herbal sedatives, valerian root, hops, skullcap, etc.)
18	Thrombolytic (blood clot buster)
19	Vermicidal (kills intestinal worms)

Kalmegh Cultivation: Harnessing Biofertilizers from Waste

There is a growing market for herbal medicines, especially those with Kalmegh. But there are concerns about their safety, effectiveness, quality, and availability. It's important to grow medicinal plants commercially to supply natural drugs to pharmaceutical companies. However, there's a problem with the lack of standard farming practices, especially when it comes to managing nutrients. Organic manures are good for the soil and help grow safe plants with better nutrient availability. It's also important to keep enough organic matter in the soil to maintain good conditions for plant growth and fertile soil for crop production.



Various biofertilizers, including those derived from cow dung, paper waste, fruit peel waste, and perishable plant waste, have demonstrated a positive impact on the growth of Kalmegh plants in field studies. These biofertilizers have contributed to an increase in the number of branches, as well as the size and length of the pods. Interestingly, plants treated with biofertilizers made from fruit peel waste exhibited early flowering, indicating the potential of these organic waste materials in enhancing plant growth and productivity. This highlights the promising role of biofertilizers in sustainable agriculture.

Phytochemical composition of Kalmegh

The leaf and stem of *Andrographis paniculata*, when extracted with acetone, methanol, and ethanol, reveal the presence of various phytochemicals and exhibit antioxidant activities.

Table 2: Total phenolic and flavonoid content of stem and leaf extracts of *Andrographis paniculata*

Solvents	Total phenols (mg GAE/g)		Flavonoids (mg rutin/100g)	
	A. paniculata (Leaf)	*A. paniculata* (Stem)	*A. paniculata* (Leaf)	*A. paniculata* (Leaf)
Acetone	19.84	21.97	51.28	63.95
Ethanol	17.63	19.82	60.71	68.27
Methanol	24.18	27.35	52.57	71.82

Table 3: Free radical scavenging activity (ABTS, DPPH and NO) of stem and leaf extracts of *Andrographis paniculata*

Solvents	ABTS (mg trolox/g)		DPPH (mg BHT/g)		NO (mg vit c/g)	
	A. paniculata (Leaf)	*A. paniculata* (Stem)	*A. paniculata* (Leaf)	*A. paniculata* (Stem)	*A. paniculata* (Leaf)	*A. paniculata* (Leaf)
Acetone	6.85	6.17	6.73	6.85	11.82	11.75
Ethanol	7.51	7.23	6.97	6.76	13.85	12.86
Methanol	9.43	8.61	7.08	7.15	12.13	12.15

Table 4: Free radical scavenging activity (MCA and H2O2) of stem and leaf extracts of *Andrographis paniculata*

Solvents	MCA (mg EDTA/g)		H2O2) (mg vit c/g)	
	A. paniculata (Leaf)	A. paniculata (Stem)	A. paniculata (Leaf)	A. paniculata (Leaf)
Acetone	13.67	11.69	3.16	2.97
Ethanol	13.82	12.18	3.92	3.18
Methanol	14.65	12.85	4.76	3.75

The high concentration of phytochemical compounds and antioxidant activities in both the leaves and stems of this crop suggest a great potential for its commercial use under various cropping systems.

In conclusion, the Kalmegh plant, with its diverse nature and growth habitat, exhibits a multitude of beneficial properties, ranging from antidiabetic to anticancer effects. The plant's significant content of phytonutrients and antioxidants, along with its positive response to various biofertilizers, underscores its potential as a subject for further research studies. Its wide array of health benefits and adaptability to different growth conditions also make it a promising candidate for medical applications. Therefore, the Kalmegh plant holds great promise for the future of sustainable agriculture and healthcare.

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7. SOIL SCIENCE

Assessment of soil loss by using Remote Sensing and Geographic Information techniques

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Soil is the earth's fragile skin that supports all life on earth. It is comprised of countless species that create a dynamic and complex ecosystem and is among the most precious resources to humans. The essential nutrients need for the growth of plant majorly supplied by soil and water. Mismanagement and Indiscriminate use of soil and water resources result in land and environmental degradation and may prove disastrous for human as well as animals. Judicious Management and conservation of soil and water is essential for sustainable productivity and environmental benefits.

Soil erosion

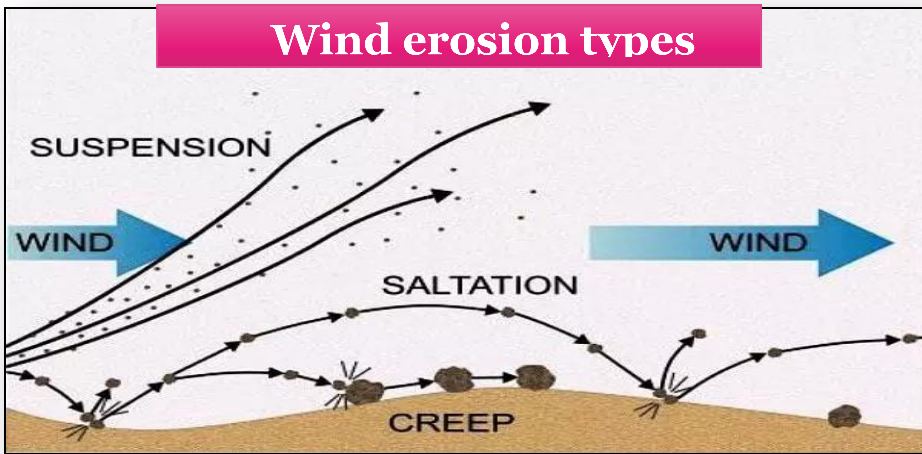
Soil erosion is a complex dynamic process by which productive surface soil are detached, transported and accumulated in a distant place resulting in exposure of subsurface soil and sedimentation in reservoirs. The soil erosion is the detachment and subsequent removal of soil particles from terrain surface due to the action of physical forces such as rainfall, runoff and wind.

Factors influencing soil erosion

- The amount and intensity of rainfall and wind velocity.
- Topography -slope of the land.
- Physical and chemical properties of soil.
- Ground cover, its nature and extent.
- Over grazing
- Intensive Agriculture
- Deforestation
- Climate change

Types of soil erosion

- Water erosion:-
  - Splash erosion
  - Sheet erosion
  - Rill erosion
  - Gully erosion
- Wind erosion: -
  - Saltation
  - Suspension
  - Surface creep



Since 1930s, several models were developed for estimating the amount of soil loss

1. **Physical Models** (Bhattarai and Dutta, 2007)
   a. Water Erosion Prediction Project (WEPP)
   b. Areal Non-point Source Watershed Environment Response Simulation (ANSWERS)
   c. Limburg Soil Erosion Model (LISEM)
   d. European Soil Erosion Model (EUROSEM) &
   e. Soil and Water Assessment Tool (SWAT)

Investigates erosion processes by synthesizing individual components and requires detailed database for all components

2. **Empirical Models**
   - Universal Soil Loss Equation (USLE)
   - Modified Universal Soil Loss Equation (MUSLE) &
   - Revised Universal Soil Loss Equation (RUSLE)

USLE & MUSLE models were criticized for their potentiality in prediction of spatial distribution of soil erosion. RUSLE, the revised version of USLE not only provides an estimation of soil loss at the plot scale, but also it represents the spatial distribution of soil erosion in an area. The combined use of geospatial technique and RUSLE model has been widely used for its simplicity and applicability over larger areas with better accuracy and low cost.

Universal Soil Loss Equation (USLE)

- Given by Wischmeir and Smith in 1978
- Designed to predict average annual soil loss caused by sheet and rill erosion on single slope. This erosion model was created for use in selected cropping and management systems
- It also applicable to non agricultural conditions (construction sites)

The USLE for estimating average annual soil erosion is

A = R*K*L*S*C*P

A = average annual soil loss in t/a (tons per acre)

R = rainfall erosivity index

K = soil erodibility factor

LS= topographic factor - L is for slope length & S is for slope

C = cropping factor

P = conservation practice factor

Modified Universal Soil Loss Equation (MUSLE)

- Given by **Renard *et al.***, (1997)
- To predict an average annual rate of soil erosion

- For a site of interest for any number of scenarios involving cropping systems, management techniques
- This is revised version of USLE model , same empirical principles

It includes some improvements:-

- Soil loss is estimated within the raster/grid GIS
- It includes monthly factor, incorporation of the profile concavity improver empirical equations of LS factor.
- It can also be applied under tropical climates with better accuracy

MUSLE Model (modified Universal Soil Loss Equation)

It was Given by Williams and Berndt (1975). This is developed to estimate sediment yield for individual storms. Replacing the rainfall factor in the USLE with a runoff factor.

The MUSLE equation is :-

$$Sy = a (Q^1 qp) b K L S C P$$

Where ,

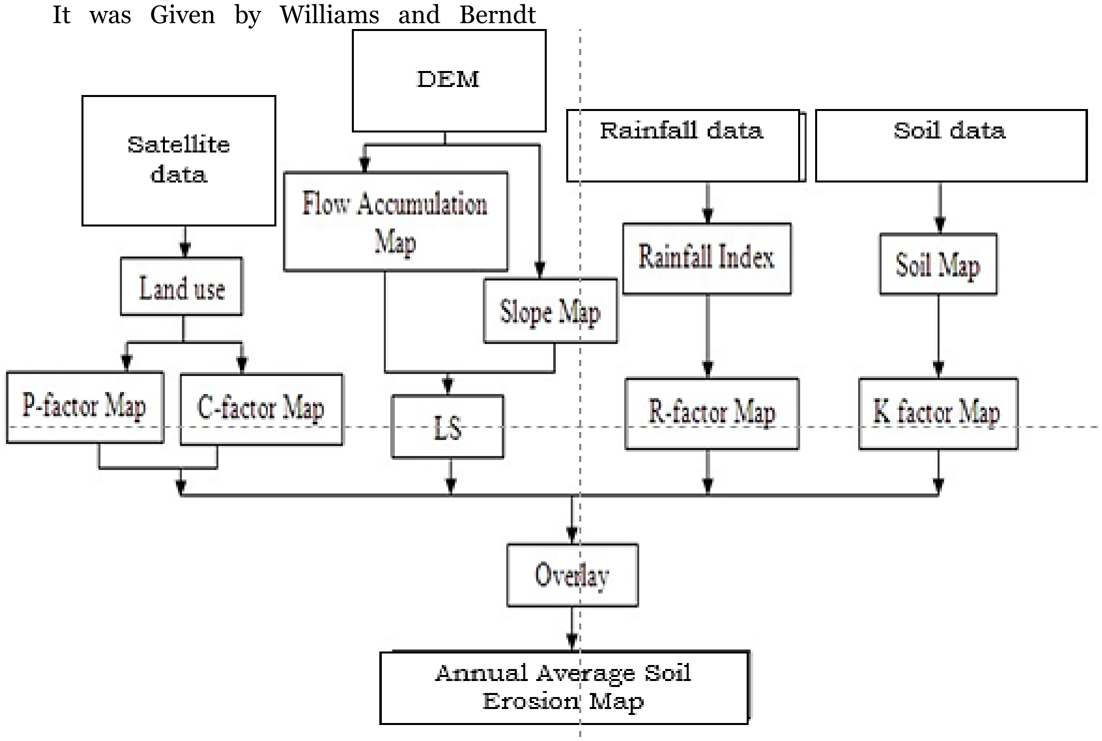
S - sediment yield (ton)

Q^1 - volume of runoff (m3)

qp- peak flow rate (m3 /sec)

a & b - location coefficients

To estimate soil erosion and to establish soil erosion management plans, many computer models have been developed and used. Remote sensing and geographic information system being a well- known computer model to assess the soil loss.



GIS (Geographical information system)

It is a technique of representing remote sensing data information in the form of thematic maps by means of visual or computer interpretation.

GIS holds spatial information in independent layers. It integrates layers by registering them to a common locational reference. Thematic layers can all be made visible at the same time or selectively and linked by common location. It allows overlaying to get

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homogenous land units and other types of information. It allows collating data from several layers for any location. Extracting information from multiple sources and combining them to answer questions. Different information about the same area at the same scale - the layered map concept

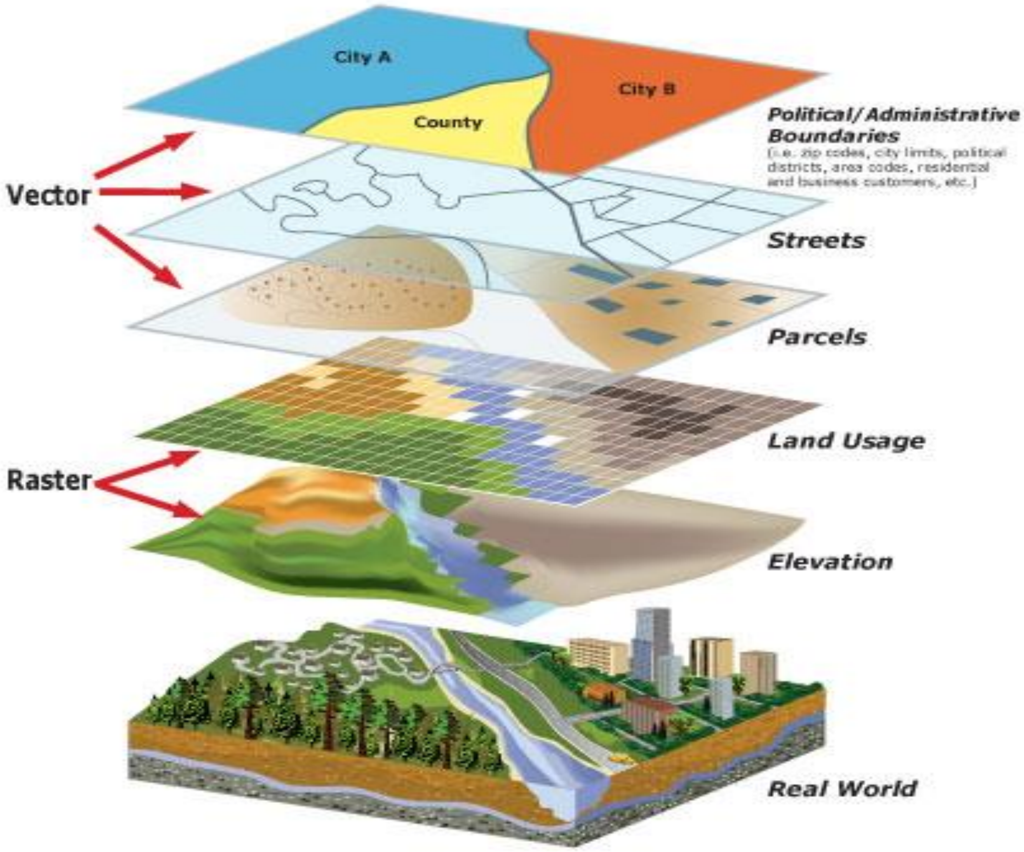

Fig 1: Two ways to visualize data in GIS

Table 1 : Comparision of three empherical models

USLE	MUSLE	RUSLE
Given by Wischmeier and Smith in 1978	Given by Williams and berndt (1975)	Given by Renard et al., (1997)
Predict average annual soil loss caused by sheet and rill erosion on single slope	Developed to estimate sediment yield for individual storms	Soil loss is estimated within the raster/grid GIS
This erosion model was created for use in selected cropping and management systems	Replacing the rainfall factor in the USLE with a runoff factor.	This model enables prediction of an average annual rate of soil erosion for a site of interest for any number of scenarios (plots) involving

		erosion control practices
Large area coverage with 90% accuracy	92 % accuracy for estimation of sediment yield on storm basis	At micro watershed level with more accuracy
Old and universally accepted model for large area soil loss estimation	Best single indicator for sediment yield prediction	This is revised version of USLE model
Applied under temperate climatic condition	Applied in tropical with less accuracy	applied under tropical climates with better accuracy

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8. HORTICULTURE

Effect of Light and its Management Strategies for Profitable Horticulture

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Introduction

Light is utilized by the plants both as primary energy source and an indication for morphogenesis. Plant growth and morphogenesis are strictly influenced by light intensity, photoperiod, and quality. Slow-moving plants which move towards or away from stimulus like light, referred as tropisms. It is vital to understand that plants perceive the light or colors of the light from the spectrum with the help of light sensors found in plants known as photoreceptors, by the protein molecule pigments. Within various pigments that promote photomorphogenic reaction in plants, the most promising are those that absorb red and blue light *i.e.*, Phytochrome and chryptochrome. These pigments control many physiological aspects in the plants.

Latest innovative and vital techniques for light management in horticultural crops

- **Reflective ground films:** In fruit crop orchards, the spectral dispersion of solar radiation varies widely as the lights enters and disperse inside the tree canopy, causing filtered and unfiltered light to form under the canopy with less light reaching the portion under canopy. To cope up this problem reflective ground films can be used in orchards. Reflective ground film is a shiny bright/ silver plastic cover to improve canopy light relations which enhance fruit quality traits such as colour and sugar content of fruits, thereby improving yield and quality of produce.

- **Photo-selective nets:** This refers to covering of crops with nets which are capable of selective filtering of penetrated solar radiation coupled with protective function. The nets are designed to screen different spectral waves of solar radiation, and/or changes direct light into dispersed light. This technique based on pure plastic products containing different chromophores and light scattering and reflective component were introduced during manufacturing.

Effect of different colored nets in horticultural crops

- **Fruit crops**: Nets have multiple uses in fruit crops such as persimmon, apples, pears, and table-grapes.
- **Vegetable crops**: Red, yellow and pearl colored shade nets increases productivity when compared to other covering practices in cases of tomato and capsicum.
- **Ornamental crops**: These plants are being cultivated traditionally in shade-net houses, shown distinct impacts to red, blue, grey, yellow and pearl coloured nets with black colored net having same shading factor.

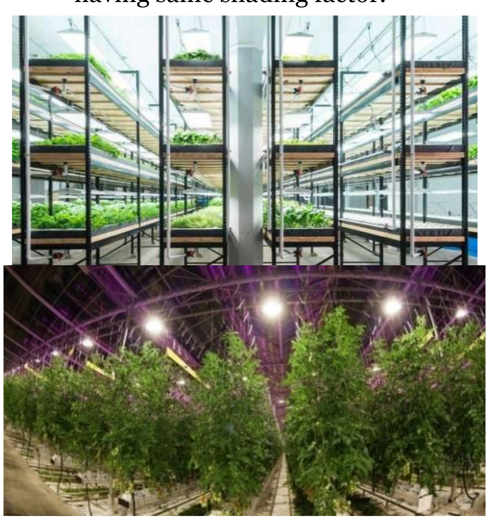

Figure: 1 Light Management for Profitable Horticulture

- **Artificial lighting**: Artificial lighting may be provided to plant as
    - **Supplemental lighting:** Supplemental lighting is the provision of artificial light in addition to sunlight, the greenhouse given under higher light intensities. Supplemental light is beneficial to provide when, a) higher light intensities, b) when ambient light intensity may limit plant growth, c) shorter day length, winter, cloudy days, d) Most economical when plant densities are high, and e) greater the number of plants per unit area and the fewer number of lamps.
    - **Photoperiod lighting:** Photoperiodic lighting is provided to fulfill the need of light duration *i. e.,* either by giving of length or by reduction of light duration known as photoperiod lighting. It is given in Lower light intensities. Under natural conditions the daylight duration differs hence the plant has developed several mechanisms to evaluate whether it is Day/ night and is it the right season for flowering or not. That's why plants are of long day & short day type. Photoperiod has key role in different aspects of plant's growth and development such as flowering, dormancy, storage organ formation and sex expression *etc.* artificial short day and long days can be created using the photoperiod lighting.

By understanding how day length influences plant growth and development in photoperiodic species, we can control the natural photoperiod to encourage vegetative growth or flowering, whichever is needed. Therefore, successful production of many crops requires knowledge of:

1. How plants react to photoperiod?
2. How photoperiod differs across the year?
3. How to modify the photoperiod for regulation of growth and development?

- LED lighting Technique: Light - emitting diode (LEDs) is potentially one of the biggest progresses in horticultural lighting in recent decades. LEDs has ability to play various roles in horticultural lighting, such as its use in controlled environment research, lighting for tissue culture, and supplemental and photoperiod lighting in the greenhouses. LED lighting systems have several unique advantages over existing horticultural lighting. Light-emitting diode technology permits higher light quantity, quality, photoperiod, and combinations thereof can be controlled with great precision.

Specific light combinations may be adjusted throughout the life of a plant to potentially optimize traits of interest such as synchronization of flowering, maintenance of vegetative growth programs, control of plant stature, or acceleration of juvenility. Blue and red LEDs can provide just the light a plant needs, making the process more efficient and growing a stronger, healthier plant.

Merits of using LED lights over traditional kind of horticultural lighting

a. LEDs emit cooler temperature, having longer life and smaller in size.
b. Safer nature of LEDs.
c. LEDs consume extremely lesser power.
d. LEDs releases lesser radiant heat
e. The danger of broken glass, high temperature and mercury in decreased with LEDs use.

Conclusion

Light is the vital environmental factors and can be manipulated with techniques such as photo selective nets, ground cover film and artificial light source being followed in developed countries for enhancing productivity. To fulfill the demand of increasing population, horticulturist will have to vital role in light management in protected cultivation in changing climatic scenario.

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9. FOOD TECHNOLOGY

Texturometer

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(TPA) is an instrumental test initially created at the General Foods Corporation Technical Center (1963) to give target estimations of surface boundaries, a main consideration of food worthiness. It was planned as a two cycle pressure performed to mimic progressive "bites". The test was initially intended to be performed through the responding activity of a uniquely planned instrument: the General Foods Texturometer. Brenan et al. (1975) have broke down the mechanical activity of the Texturometer in some detail. Bourne adjusted it to the Instron Universal Testing Machine and Bourne's paper

(1978).

As per Szczesniak, one of the originators of the tests, as the critical reference to TPA (Szczesniak, 1996) with in excess of 950 references. Surface analyzers, or texturometers, are instruments used to apply logical techniques to the estimation and examination of item surface. Such hardware is utilized to assess and control the variables influencing quality, preparing, dealing with and timeframe of realistic usability, empowering the maker to comprehend buyer propensities and acknowledgment standards. Food surface, through touch, is vital factor for the end client, notwithstanding taste and smell.

The test is basic and the textural boundaries concluded naturally reasonable, it has gotten extremely well known. Nonetheless, Breene (1975) noticed that changes to the first meaning of the boundaries have been very disordered and "significant deficiencies of studies including TPA incorporate poor exploratory plan, nonappearance or ill-advised utilization of factual investigation and fragmented portrayal of trial materials and testing conditions. As of late, Szczesniak highlighted 'abuse' of the strategy, and a helpless comprehension of the importance of the boundaries and the way wherein the technique ought to be executed refering to for instance. The utilization of an entering needle (instead of a compacting plate): infiltrating the example twice in a similar spot prompts futile information and the test ought not be called TPA.

Boundaries of Texturometer

Szczesniak (1963) and Brandt et. al. (1963) gathered the textural properties as starting (on first chomp: hardness, thickness, weakness), masticatory (during biting: stickiness, chewiness, adhesiveness) and leftover (pace of breakdown, sort of breakdown). The first texturometer actual boundaries/properties characterized by the General Foods Corporation bunch are

TPA parameter (SI unit)	Definition
Hardness (N)	Force required for a pre determineddeformation
Fracturability (N)	Force at the first significant break in the curve
Cohesiveness (no unit)	Strength of internal bonds in the sample
Adhesiveness (J)	Work required to overcome the sticky forces between the sample and the probe
Gumminess (N)	Energy needed to disintegrate a semisolid food until it is ready to swallow
Stringiness (m)	Distance travelled by the probe during the negative force area
Chewiness (J)	Energy needed to chew a solid food until it is ready forswallowing
Springiness (m)	Originally called “Elasticity”: rate at which a deformed sample returns to its original size andshape

Principle of Texturometer/ Texture Analyzer

The principle of a texture estimation framework is to genuinely disfigure a test in a controlled way and measure its reaction. The qualities of the power reaction are because of the example's mechanical properties, which connect to explicit tactile surface credits. A surface analyzer applies this standard by playing out the technique naturally and demonstrating the outcomes outwardly on an advanced mathematical showcase, or screen. Powers made during this development are controlled to reproduce shopper connections, for instance the conditions that food sources are presented to when we eaten or prepared. This empowers the immediate estimation and hence the capacity to anticipate how an item will perform or feel .There are essential test strategies intended to twist tests in manners which reproduce these perplexing human associations.

Applications

Quality Control, Product Development and R&D

Food	Cosmotics	Pharmaceuticals	Materials

Fruits and vegetables	Mascara	Ointments	
Dairy products like butter cheese	Lipstick and powder	Tablets	Wax
Bakery products	Creams	Gelatins	Rubber
Meat products	Soap bars		

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10. HORTICULTURE

Microgreens

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Microgreens are vegetable greens harvested just after the cotyledon leaves have developed (and possibly, with one set of true leaves). They are used as a nutrition supplement, a visual enhancement, and a flavor and texture enhancement. Microgreens can add sweetness and spiciness to foods. Microgreens are considered baby plants, falling somewhere between a sprout and baby green. Among upscale grocers, they are now considered a specialty genre of greens, good for garnishing salads, soups, sandwiches, and plates.

Different Types of Microgreens

Microgreens can be grown from many different types of seeds.The most popular varieties are produced using seeds from the following plant families :

- **Brassicaceae family:** Cauliflower, broccoli, cabbage, watercress, radish and arugula
- **Asteraceae family:** Lettuce, endive, chicory and radicchio
- **Apiaceae family:** Dill, carrot, fennel and celery
- **Amaryllidaceae family:** Garlic, onion, leek
- **Amaranthaceae family:** Amaranth, quinoa, swiss chard, beet and spinach
- **Cucurbitaceae family:** Melon, cucumber and squash

Cereals such as rice, oats, wheat, corn and barley, as well as legumes like chickpeas, beans and lentils, are also sometimes grown into microgreens.

Nutritional aspect

Microgreens are packed with nutrients. While their nutrient contents vary slightly as most varieties tend to be rich in potassium, iron, zinc, magnesium and copper.They are a great source of antioxidants.Their nutrient content is concentrated, which means that they often contain higher vitamin, mineral and antioxidant levels than the same quantity of mature greens. In fact, research comparing microgreens to more mature greens reports that nutrient levels in microgreens can be up to nine times higher than those found in mature greens. Researches also show that they contain a wider variety of polyphenols and other antioxidants than their mature counterparts.

Health benefits

They contain high amounts of vitamins,minerals and beneficial plant compounds.They may reduce the risk of following diseases :

- **Heart disease: Microgreens** are a rich source of polyphenols, a class of antioxidants linked to a lower risk of heart disease. Animal studies show that microgreens may lower triglyceride and bad LDL cholesterol levels.
- **Alzheimer's disease:** Antioxidant-rich foods, including those containing high amounts of polyphenols,may be linked to a lower risk of Alzheimer's disease.
- **Diabetes:** Antioxidants may help reduce the type of stress that can prevent sugar from properly entering cells. In lab studies, fenugreek microgreens appeared to enhance cellular sugar uptake by 25–44%
- **Certain cancers:** Polyphenol-rich microgreens may be expected to lower the risk of various types of cancer.

Grow Your Own Microgreen

Microgreens are easy and convenient to grow, as they don't require much equipment or time. They can be grown year-round, both indoor or outdoors. For this we need:

- Good-quality seeds.
- A good growing medium, such as a container filled with potting soil or homemade compost. Alternatively, you can use a single-use growing mat specifically designed for growing microgreens.
- Proper lighting — either sunlight or ultraviolet lighting, ideally for 12–16 hours per day.

Tips to Grow

- Fill your container with soil, making sure you don't over-compress it, and water lightly.
- Sprinkle the seed of your choice on top of the soil as evenly as possible.
- Lightly mist your seeds with water and cover your container with a plastic lid.
- Check on your tray daily and mist water as needed to keep the seeds moist.
- A couple of days after the seeds have germinated, you may remove the plastic lid to expose them to light.
- Water once a day while your microgreens grow and gain color.
- After 7–10 days, your microgreens should be ready to harvest.

How to Include Microgreens in OurDiet

- There are many ways to include microgreens in our diet.
- They can be incorporated into a variety of dishes, including sandwiches, wraps and salads.
- Microgreens may also be blended into smoothies or juiced. Wheatgrass juice is a popular example of a juiced microgreen.
- Another option is to use them as garnishes on pizzas, soups, omelets, curries and other warm dishes.

Conclusion

Microgreens are flavorful and can easily be incorporated into your diet in a variety of ways.They are also generally very nutritious and may even reduce your risk of certain diseases.They are easy to grow at home, they are an especially cost-effective way to boost nutrient intake without having to purchase large quantities of vegetables. As such, they are a worthwhile addition to our diet.

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11. HORTICULTURE

Training Systems for Higher Yield and Quality Fruits in Cucumber

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Introduction

Cucumber (*Cucumis sativus* L.) is an important summer vegetable crop grown in the tropical and temperate regions of the world and is considered as fourth most important vegetable crop after tomato, cabbage and onion in Asia.It belongs to the family cucurbitaceae and is native to Southern Asia.

Cucumber is a creeping vine, grows on trellises and wrapping around supports with thin spiralling tendrils. The plant has large leaves, form a canopy over the fruit. Botanically the fruit is called as pepo and it is mostly referred as super food having no side effect. The fruits and seeds possess cooling properties. Fruits eaten at immature stage are good for people suffering from constipation, jaundice and indigestion. Cucumber has a bitter principle called "cucurbitacin" and is used in ayurvedic and unani medicines. It is a primary source of vitamins and minerals and also considered as good for diabetic patient as it contains low sugar and help in the burning of excess fat in the body.

Need for Training and Pruning

India has emerged as the origin of the finest cucumber cultivation in various aspects. Even though, greenhouse cucumber farmer often encounters many problems like identification of suitable varieties and suitabletraining systems for plant growth manipulation with respect to yield. Moreover, cucumber crop exhibits overcrowding of vines within a short time due to itsfast growth habit, causes problems for performing various cultural operations and this dense canopy of leaves shades the fruits, causing them to be pale.

Training and pruning at proper time fetch us higher yield of quality fruits. Training the plants will not only facilitates easy cultural operations, but also permits early harvesting with quality fruits.Excessive pruning of leaves causes the plants to stop producing flowers. Hence it is important to maintain sufficient foliage on the plant for adequate rate of photosynthesis. Manipulation of canopy architecture through pruning and training together with appropriate spatial arrangements has been identified as key management practice for obtaining maximum marketable fruits in greenhouse crops.

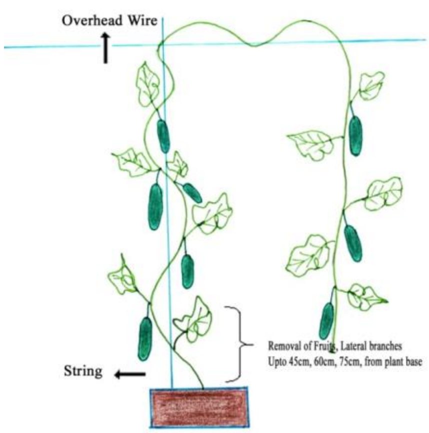
Different Training Systems

The training systems given below are

proved beneficial and been followed by many farmers around the globe based on the climatic conditions prevailing in the area of cultivation. Detailed information regarding the training systems is given below.

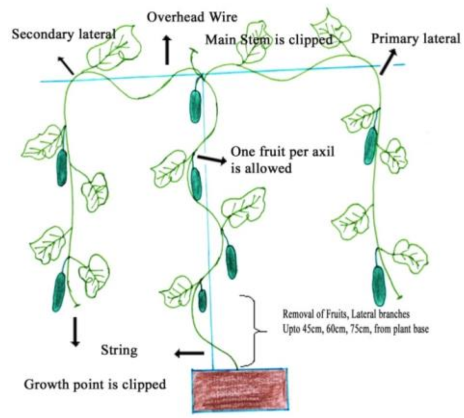
Single Head Training System

In single head training system, the vine was trained on to the overhead wire, with a single stem. All the flower buds and lateral branches were removed from the base of the vine up to different heights of 45, 60 and 75 cm up to 90 cm. Fruits are allowed on the main stem at the rate of one per axil. When the vine reached the overhead wire then allowed it to grow towards the ground direction.



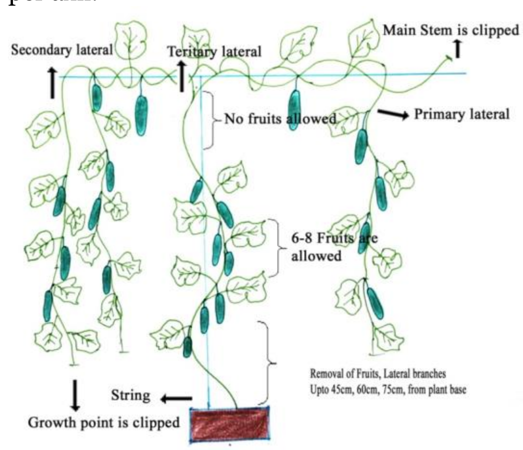
Umbrella Training System

In umbrella training system all the flowers and lateral branches are removed up to a height of 60 cm from the ground level. Then allow the one fruit per axil on the main stem until it reaches overhead wire. When the main vine reaches the overhead wire, the growing point is removed and then two healthy vigorous branches were allowed to grow along the wire up to 15 cm and then trained to grow downwards with a fruit in each axil.



Low Middle Training System

In low middle training system all the flowers and lateral branches are removed up to a height of 60 or 75 cm from the ground level and allow 6 – 8 fruits, then leave the vine without any fruits until it reaches the overhead wire. When the main vine reaches the overhead wire the main stem is winded on to the cable up to 30 cm and then growing point is removed and allow three healthy laterals, one lateral in the direction of the main stem along the wire for 20 cm and the other two laterals in opposite direction of the main stem for 20 and 30 cm along the wire. These three branches are allowed to grow downwards with a fruit each per axil.



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12. ENTOMOLOGY

Eco-Friendly Pest Control Using Botanical Pesticides

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Introduction

Plants have evolved for 400 million years ago and have developed protection mechanisms to defend themselves from insect pest attack such as repellents, antifeedants and even insecticidal effects. Ancient civilizations used botanical pesticides, but synthetic ones replaced them after World War II, raising environmental and health concerns. Botanical insecticides, derived from plant parts, offer a promising alternative with lower risks. However, only a fraction of plant species has been evaluated for pesticidal properties. Compounds like alkaloids and terpenoids from plants offer protection. Certain plant oils repel insects too. Botanical pesticides degrade quickly and also its efficacy depends on factors like raw material availability and weather. Natural pesticides aren't inherently safer, as some can be toxic. Usage is influenced by formulation, active ingredient, exposure period, climate, and user demographics.

Some Important Botanical Pesticides:

- **Neem and Neem products (Azadirachtin):** Neem compounds, particularly azadirachtin, target insects' hormonal systems, disrupting growth and reproduction. Its diverse modes of action include acting as a growth inhibitor, antifeedant, repellent, and sterilant. Neem formulations are available in different concentrations, making them versatile for various pest control needs. Farmers in Asia traditionally use neem to protect stored grains from pests like weevils and flour beetles.
- **Nicotine:** Derived from tobacco plants, nicotine is a potent nerve poison for insects, mimicking the neurotransmitter acetylcholine. It selectively affects certain types of insects by interfering with their nervous system. Nicotine acts quickly, causing uncontrolled nerve firing and paralysis in insects.
- **Rotenone:** Found in certain plant roots (*Derris*, *Lonchocarpus*, and *Tephrosia*), rotenone acts as a contact and systemic insecticide, disrupting cellular metabolism in insects. It's particularly effective against chewing insects and must be ingested to be toxic. Rotenone is also used as a fish poison in water management programs due to its toxicity to fish.
- **Sabadilla:** Sabadilla, derived from South American lily (*Schoenocaulon officinale*), contains toxic alkaloids that affect nerve cell membrane action in insects. It causes paralysis and death in insects by disrupting nerve function.
- **Ryania:** Obtained from Caribbean shrub (*Ryania speciosa*), ryania acts as a gastrointestinal toxin for insects, causing them to stop feeding shortly after ingestion. While not causing immediate paralysis, it leads to cessation of feeding and eventual death in insects.
- **Pyrethrum and Synthetic pyrethroids:** Pyrethrum, derived from dried chrysanthemum flowers, contains insecticidal compounds called pyrethrins. Pyrethrins disrupt nerve impulse transmission in insects, leading to rapid knockdown and eventual death. They are effective against a wide range of insects and are

relatively safe for mammals. Synthetic pyrethroids are chemically modified versions of natural pyrethrins, designed for enhanced efficacy and photostability.

- **Melia extracts:** Extracts from Melia trees contain triterpenoids similar to those found in neem, which act as feeding deterrents and stomach poisons for insects. These compounds disrupt insect feeding and digestion, leading to reduced insect populations. Melia extracts are effective against a variety of insect pests and are relatively safe for mammals.
- **Annonaceous acetogenins:** Found in tropical *Annona* species, acetogenins function similarly to rotenone, inhibiting energy synthesis in insects and mammals. These compounds disrupt mitochondrial function in insect cells, leading to paralysis and eventual death. Annonaceous acetogenins are particularly effective against chewing insects and can be a valuable tool in integrated pest management strategies.

Standardization of Botanical Extracts and Regulatory Approval

Achieving chemical standardization is essential for the reliable efficacy of botanical pesticides. Refined formulations based on compounds like pyrethrum, neem, and rotenone have shown promise, but crude preparations often lack proper quantification of active chemicals. Standardization requires robust analytical methods, specialized equipment, and adequate storage facilities. Moreover, the inherent stability of active principles in plant material influences blending and storage processes, adding complexity to the standardization endeavour. Regulatory approval presents a formidable hurdle to the marketing of botanical pesticides, particularly in industrialized countries. Exemptions for certain plant essential oils in the United States have facilitated rapid development and commercialization, but broader acceptance remains limited. Harmonization of regulatory standards across major jurisdictions is crucial to promote the introduction of more biopesticides.

Current Status in India and Role in the Future

India has registered four botanical pesticides: Azadirachtin (Neem Based Formulations), Citronella, Pyrethrum, and Eucalyptus Leaf Extract. Among these, Azadirachtin is the most widely used in agricultural pest management systems. While growth potential in industrialized countries is limited, botanical pesticides hold significant promise in integrated pest management and public health applications. In developing countries, affordability and safety concerns underscore their potential. However, comprehensive efficacy and safety demonstrations are essential for effective utilization.

Conclusion

Botanical pesticides offer promising avenues for sustainable pest management, leveraging advantages such as familiarity, rapid degradation, and reduced environmental impact. Overcoming challenges such as standardization and regulatory approval is crucial to realizing their full potential. Concerted efforts in research, regulation, and application are necessary to promote the widespread adoption of botanical pesticides as viable alternatives to synthetic chemicals in agricultural pest management.

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