



ISSN:2583-9071

VOLUME 3, ISSUE 8 | AUGUST 2025

A STEP TOWARDS AGRICULTURE

Agri Roots

e-Magazine



CONTAMINATED
ROOTS,

“Compromised Health”

AUGUST 2025

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"WHEN SOIL TURNS
TOXIC, THE ROOTS OF
HEALTH—BOTH PLANT
AND HUMAN—BEGIN
TO DECAY."

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from the editor

Soil, the foundation of all terrestrial ecosystems, plays a crucial role in sustaining agricultural productivity and food security. However, the increasing accumulation of heavy metals—such as lead (Pb), cadmium (Cd), arsenic (As), and mercury (Hg)—in agricultural soils is emerging as a silent threat to both crop health and human well-being. These toxic elements, often introduced through industrial effluents, excessive use of agrochemicals, untreated wastewater irrigation, and atmospheric deposition, can persist in the soil for decades, gradually degrading its quality.

As heavy metals enter the food chain through crop uptake, they can adversely affect plant growth, reduce yields, and compromise the nutritional value of produce.

More alarmingly, the bioaccumulation of these metals in edible plant parts poses serious health risks to consumers, including kidney damage, neurological disorders, and even cancer with prolonged exposure.

This issue calls for urgent interdisciplinary attention—encompassing soil science, environmental toxicology, agronomy, and public health—to monitor, manage, and mitigate the contamination. It also underscores the need for sustainable agricultural practices, stringent regulatory frameworks, and increased awareness among stakeholders.

Dr. Deepak Kumar
FOUNDER & EDITOR

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AGRI ROOTS E-MAGAZINE

Heavy Metals Build-Up in Soil and Effects on Crops and Consumer Health

www.agrirootsmagazine.in

ISSN: 2583-9071

ARTICLE ID: 0227

Vineet Kumar, Susmita

School of Agriculture, Galgotias University, Greater Noida (U.P.)

Hheavy metals, including cadmium (Cd), lead (Pb), arsenic (As), chromium (Cr), mercury (Hg), and others, are naturally occurring elements found in the earth's crust. While trace amounts of some of these metals are essential for biological processes, their excessive accumulation, primarily due to anthropogenic activities, has become a growing environmental concern. Major sources of heavy metal contamination in agricultural soils include the indiscriminate use of chemical fertilizers and pesticides, industrial effluents, mining operations, wastewater irrigation, atmospheric deposition from vehicular and industrial emissions, and the disposal of municipal solid waste. These activities introduce elevated concentrations of toxic metals into the soil system, disrupting its physico-chemical and biological balance.

The persistence of heavy metals in soils and their non-degradable nature means they can

accumulate over time, leading to long-term contamination. This adversely affects soil fertility by interfering with microbial activity, nutrient cycling, and plant root development. More alarmingly, heavy



metals are readily absorbed by plants from the contaminated soil and translocated to edible plant parts. As a result, food crops grown in such soils may contain unsafe levels of heavy metals, posing a direct threat to food safety and human

health.

Therefore, the presence and accumulation of heavy metals in agricultural soils not only compromise soil health and crop productivity but also raise serious concerns regarding environmental sustainability. It is imperative to monitor soil contamination levels, regulate pollutant sources, and adopt remediation strategies to mitigate heavy metal accumulation and safeguard both ecosystem and human well-being.

Sources of Heavy Metal Accumulation in Soil

The primary sources of heavy metals in agricultural soils include industrial emissions, application of sewage sludge, use of pesticides and fertilizers, wastewater irrigation, and fly ash from thermal power plants. Numerous studies highlight the pivotal role of chemical fertilizers in the build-up of heavy metals in cultivated soils. According to Atafar et al. (2008), the use of phosphate fertilizers significantly increased levels of Cd, Pb, and As in wheat-cultivated soils, especially when fertilizer application rates exceeded crop needs.

Similarly, Bai et al. (2010) found that land use patterns significantly affect metal accumulation, with greenhouse vegetable fields showing the highest concentrations of heavy metals, particularly Cd and Cu, compared to maize or forest lands. The accumulation was strongly linked to the overuse of chemical and organic fertilizers containing trace metal impurities.

Additionally, the application of fly ash as a soil amendment proposed as a method for soil improvement can elevate heavy metal levels in soil and crops if not carefully managed. Nayak et al. (2015) reported increased concentrations of Zn, Fe, Cu, Mn, Cd, and Cr in soil at higher fly ash application rates, with trace metals also detected in rice grains grown in these soils.

Soil and Plant Factors Influencing Uptake

Heavy metal uptake by plants is governed by various soil characteristics including pH, cation exchange capacity, organic matter, and redox potential. Cataldo and Wildung (1978) emphasized that metal solubility, influenced by these factors, plays a critical role in

determining how much of a metal becomes available to plant roots. Acidic soils, for example, enhance the solubility of many heavy metals, increasing their bioavailability and risk of plant uptake.

Different crops and even different varieties within the same species vary in their capacity to absorb and translocate heavy metals. Wang and Li (2014) found that wheat tends to accumulate higher concentrations of heavy metals compared to corn, particularly Cd and Hg. This makes cereal grains a key vector for heavy metals entering the human diet.

Effects on Crop Health and Yield

Heavy metal contamination negatively impacts plant growth and productivity. Metals such as Cd and Pb interfere with physiological processes like photosynthesis, nutrient uptake, and enzyme activity. Sharma and Agrawal (2005) observed reductions in biomass and yield in crops exposed to elevated heavy metal levels. Additionally, these metals can alter antioxidant enzyme levels and reduce the nutritional quality of produce.

Health Risks to Consumers

Heavy metals taken up by crops ultimately enter the human food chain, especially through staple foods like cereals and vegetables. Chronic exposure to heavy metals can lead to severe health conditions including neurotoxicity, kidney and liver damage, skeletal disorders, and various cancers. Cd, for instance, is nephrotoxic and a known carcinogen, while Pb affects neurological and cardiovascular systems. Children are particularly vulnerable to the toxic effects of Pb and Cd due to their developing systems.

Zwolak et al. (2019) highlighted that even low concentrations of heavy metals in vegetables pose a health threat, especially when consumed regularly. Regulatory bodies such as the EU and WHO have established maximum permissible levels for heavy metals in food to mitigate these risks, but these are often exceeded in produce from contaminated areas.

Conclusion and Recommendations

The build-up of heavy metals in soil and their transfer into crops and ultimately humans is a growing concern worldwide. To ensure food safety and sustainable agriculture, the following steps are essential:

- Regulate fertilizer and pesticide use, favouring those with minimal heavy metal content.
- Monitor soil and crop metal concentrations regularly, especially in high-risk areas like those near industrial zones.
- Implement soil amendments and pH adjustments to reduce metal bioavailability.
- Promote phytoremediation using plant species known to extract or stabilize heavy metals.

A coordinated approach involving farmers, policymakers, scientists, and consumers is vital to curb the silent yet severe threat of heavy metal contamination in our food systems.

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Fibre Plants of Uhl Valley, Himachal Pradesh: A Study of Traditional Knowledge

www.agrirootsmagazine.in

ISSN: 2583-9071

ARTICLE ID: 0228

Savita Rani*¹, Syed Mudassir Jeelani², Sonika Kalia³, Ruchi³

¹School of Agricultural Sciences, Baddi University of Emerging Sciences and Technology Baddi (H.P.)
173205, India

²ICAR- Central Institute of Temperate Horticulture, Old Air Field, Rangreth, Srinagar, (J&K) 91132 India

³Department of Biotechnology, School of Applied and Life Sciences, Uttarakhand University, Dehradun 248007

The Uhl Valley, nestled in the Kangra District of Himachal Pradesh, is a serene and picturesque region that offers a blend of

natural beauty, adventure, and cultural heritage. It is primarily known for the Uhl River, which originates from the Thamsar Glacier in the Dhauladhar range and flows through the valley, passing through villages like Barot, Badgram, Nargu Wildlife Sanctuary and

Rajgundha & Kukargundha Valleys. Uhl Valley boasts a diverse range of fibre plants that have been deeply ingrained in the local culture and economy for centuries. The indigenous communities have traditionally utilized these plants to craft a variety of essential products, including sturdy ropes, intricately woven baskets, and warm clothing.

Importance of Fibre Plants

Fibre plants play a vital role in the lives of people residing in the Uhl Valley. They provide a source of income, food, and medicine, while also contributing to

the region's biodiversity.

The traditional knowledge associated with these plants has been passed down through generations, highlighting the significance of preserving cultural heritage.

Common Fibre Plants in the Region

Some of the commonly used fibre plants in the region include:

***Agave cantula*:** It commonly known as "Rambans" or "Kandala," is a drought-tolerant fiber plant native to the Indian Himalayan region. It thrives in dry, exposed waste places and scrub jungles, typically at elevations below 1,300 meters. It is a robust, acaulescent shrub with thick, flat, oblong-lanceolate leaves. The



flowering is start from July to December, producing orange-yellow or yellow corolla flowers. It prefers dry, well-drained sandy loam soils and can tolerate temperatures ranging from 10°C to 38°C. Mature leaves, typically 3–4 years old, are harvested and stripped of terminal and marginal spines. The leaves are then beaten with a wooden hammer to separate the fibers, which are subsequently sun-dried. The fibers are used to make ropes, mats, twines, nets, and cordage. They are finer but less strong than those of sisal, making them more suitable for spinning into yarn.

***Bombax ceiba* L.:** It is commonly known as the Silk Cotton Tree or Semal belongs to the family Bombacaceae. his deciduous tree is recognized for its striking red flowers and cotton-like seed floss, which has various uses. It grows up to 25 meters tall with palmate leaves; bright red, solitary, and terminal, blooming from January to May. The white, fluffy fibers from the seed pods are extracted and carded into thread. These fibers are primarily used as stuffing material for pillows, cushions, and similar items. In North India, these fibers are also utilized in pillows

***Cannabis sativa*:** Local Names of *Cannabis sativa* is Bhang & Charas belongs to the family canabinaceae. It predominantly found in Chhota Bhangal and Karsog regions of Uhl Valley. The fiber from the stems is

exceptionally strong and durable, making it ideal for producing ropes, mats, and other woven items. After harvesting, the plant is dried, and the seeds are separated. The fiber is then extracted from the stems and branches. While the plant has narcotic properties, its fiber extraction is a traditional practice.

***Grewia optiva* J. R.:** Locally known as bhimal or buel, is a valuable multipurpose tree species having family Tiliaceae widely found in the Uhl Valley of Himachal Pradesh. The plant is highly regarded for its strong bast fibers, which are extracted from its branches and used to make ropes, mats, and other cordage materials. In addition to its fiber-producing value, *Grewia optiva* is an important source of nutritious fodder during the dry winter months, with leaves rich in protein. It also serves as fuel wood and contributes to soil conservation by preventing erosion and improving soil fertility. With its integration into farming systems in the Uhl Valley, it supports both ecological sustainability and rural livelihoods, making it a key species in mountain agro forestry.

***Urtica dioica* L.:** Commonly known as stinging nettle, this plant belongs to the Urticaceae family and is traditionally used in various ways in the Uhl valley. It is used to make mats, chapals and the pulp is used to make paper.

Table 1—Traditional uses of plant species in Uhl valley of Kangra district in Himachal Pradesh.

S. No	Scientific name / Family	Habit	Habitat/Distribution	Part used	Mode of utilization/Uses
1.	<i>Agave cantula</i> Roxb./Agavaceae	Shrub	On barren hills/ Bangladesh, India, Mexico Nepal and Pakistan.	Leaf	Making ropes and mats

2.	<i>Bombax ceiba</i> L./ Bombacaceae	Tree	on sunny hilly sides/ India, Australia and China	Grows, Fruits	Stuffing cushions, mattresses and pillows
3.	<i>Cannabis sativa</i> L./Cannabinaceae	Herb	Grows abundantly on roadside,/ China, India, Pakistan, Iran	Stem, Bark	Making ropes, <i>Pula</i> ,tying ropes for cattle
4.	<i>Grewia optiva</i> J. R. Drumm. ex Burret/Tiliaceae	Tree	Distributed near villages / Himalayan regions in Pakistan, Nepal, India.	Stem, Bark	Making ropes and Baskets.
5.	<i>Urtica dioica</i> L./ Urticaceae	Herb	Near road sides /widespread in the temperate regions of both hemispheres.	Stem, Bark	Making ropes, mats and threads



Plate 1—Various processes and products of plant fibers used in the study area

Traditional Practices

The local communities in Uhl Valley have cultivated distinctive traditional practices for harvesting, processing, and utilizing fiber plants, which are intricately woven into the region's cultural fabric. These time-honored practices, passed down through generations, not only reflect the community's resourcefulness but also contribute significantly to their cultural identity. However, the traditional knowledge associated with fiber plants is facing erosion due to the influences of modernization and urbanization. As younger generations migrate to urban areas and adopt modern lifestyles, the risk of losing this valuable knowledge increases. Therefore, it is essential to document and preserve this traditional wisdom to ensure the sustainable use of these plants and the preservation of the region's cultural heritage.

Conservation of Fibre Plants

Conservation of fibre plants and the promotion of their sustainable use are critical for the preservation of both cultural heritage and ecological balance in the Uhl Valley region. The diverse array of fibre plants, which

have been utilized for generations in various traditional practices, not only provides important materials for local industries but also plays a vital role in maintaining the ecological integrity of the region. These plants, often deeply intertwined with local customs, agricultural practices, and crafts, represent a cornerstone of the region's socio-economic and cultural landscape. As such, there is a growing recognition of the need to document and conserve these resources while simultaneously ensuring their sustainable management for future generations. One of the key elements in these conservation efforts is the documentation of traditional knowledge surrounding fibre plants. Over time, indigenous and local communities have developed an extensive body of knowledge related to the cultivation, harvesting, and processing of fibre plants. This traditional ecological knowledge (TEK) offers invaluable insights into the sustainable use of these plants, reflecting a deep understanding of the local environment and its ecological cycles. Researchers are working to document this knowledge through a combination of ethnobotanical studies, field surveys, and collaborative work with local practitioners. By preserving this knowledge, researchers aim to protect the cultural heritage associated with fibre plants and ensure that future generations can continue to benefit from these resources without compromising the health of the ecosystem.

Moreover, the documentation of traditional knowledge serves a dual purpose. It not only preserves cultural practices but also enhances our understanding of how these practices can contribute to the conservation and

sustainable management of fibre plant species. Many traditional methods of plant cultivation and harvesting are based on principles of ecological sustainability, such as crop rotation, controlled harvesting techniques, and selective breeding. These practices, which have been honed over centuries, can offer valuable lessons in biodiversity conservation and sustainable resource management. Integrating traditional knowledge into modern conservation strategies could, therefore, lead to more effective approaches that balance cultural preservation with environmental stewardship.

Another important aspect of conservation efforts in the Uhl Valley is the promotion of sustainable harvesting practices. Overexploitation of fibre plants, often driven by commercial demands, poses significant threats to the long-term viability of these species. Unsustainable harvesting can lead to habitat degradation, reduced plant populations, and the loss of important ecological functions. To address these concerns, conservationists and local communities are working together to develop and implement sustainable harvesting guidelines. These guidelines are based on principles such as maintaining healthy plant populations, using non-invasive harvesting methods, and ensuring that harvesting activities do not negatively impact the broader ecosystem. Furthermore, sustainable harvesting practices are designed to provide economic benefits to local communities, helping to reduce the pressures associated with overharvesting and promoting long-term economic sustainability.

Community engagement is a cornerstone of the conservation initiatives in the region. Local

communities, who have historically relied on fibre plants for food, medicine, and trade, are essential partners in the conservation process. By involving local stakeholders in the development and implementation of conservation strategies, the Uhl Valley's conservation efforts are grounded in the realities of community needs and aspirations. Educational programs, workshops, and participatory decision-making processes are being used to raise awareness about the importance of fibre plants and the need for their sustainable management. These initiatives not only promote environmental conservation but also empower local communities to take an active role in the protection and responsible use of their natural resources.

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Conclusion

In conclusion, the conservation of fibre plants in the Uhl Valley is a multifaceted endeavor that requires the integration of traditional knowledge, sustainable harvesting practices, and community participation. By fostering a deeper understanding of the ecological, cultural, and economic significance of fibre plants, these efforts aim to preserve both the cultural heritage of the region and its natural resources for future generations. In doing so, they contribute to the broader goals of sustainable development and environmental stewardship, ensuring that fibre plants continue to play a central role in the lives of local communities while maintaining the ecological balance of the region.

The Role of Cheese in Nutrition and Health: A Focus on Probiotic Enrichment and Composition

ARTICLE ID: 0228

Garima Dixit¹, Sadhna Singh², Tripti Verma³

¹Research Scholar, Department of Food and Nutrition, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya

²Professor, Department of Food and Nutrition, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya

³Assistant Professor, Department of Food and Nutrition, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya

Probiotics are defined as live microorganisms that, when administered in sufficient quantities, confer health benefits to the host.

These beneficial microbes play vital roles in enhancing immunity, protecting against pathogenic infections, improving lactose digestion, and reducing cholesterol levels. A variety of dairy products—such as yogurt, cheese, and other fermented milk items—are commonly used as vehicles for probiotic delivery. For probiotics to exert their beneficial effects, their concentration at the time of consumption should typically range between 5.0 and 7.0 log cfu/g. Among dairy products, cheese is considered one of the most effective carriers of probiotic bacteria due to its

buffering capacity, which protects the probiotics in the acidic environment of the gastrointestinal tract. This buffering effect increases the pH during digestion,



creating a favorable condition for probiotic survival. Various types of cheeses—such as Karish, Cheddar, Gouda, Ras, Cottage cheese, and other fresh or white cheeses—have been developed using specific

probiotic strains. These strains are selected based on the type of cheese and its manufacturing parameters. Fresh cheese or cheese in the early ripening phase typically has a higher count of lactic acid bacteria, whereas non-lactic acid bacteria tend to increase with extended ripening time. Importantly, incorporating

probiotics should not compromise the cheese's sensory or textural quality.

Cheese offers unique advantages over yogurt and fermented milk as a delivery system for probiotics. Its inherent buffering action in the gastrointestinal tract enhances the survival of probiotics by mitigating the effects of gastric acidity, thus promoting their efficacy.

Nutritional and Functional Attributes of Cheese

Cheese has played a significant role in human diets since ancient times, initially serving as a concentrated form of milk with extended shelf life. Its high fat and protein content made it a valuable energy source for early populations. Today, scientific research continues to highlight cheese as a nutritionally dense food, abundant in essential nutrients such as proteins, amino acids, bioactive peptides, fats, fatty acids, vitamins, and minerals. A notable benefit is that ripened cheese contains minimal to no lactose, making it suitable for lactose-intolerant individuals.

Recent studies have identified two bioactive tripeptides—valyl-prolyl-proline (VPP) and isoleucyl-prolyl-proline (IPP)—in fermented milk with *Lactobacillus helveticus*, which exhibit blood pressure-lowering effects. These peptides have also been detected in certain cheese types in significant amounts.

Cheese is widely appreciated for its sensory appeal and versatility, making it suitable for all age groups and dietary applications. Its popularity and

multifunctionality also create avenues for its commercial development as a probiotic food. However, successful production of probiotic cheeses requires detailed knowledge of their processing steps and a comprehensive understanding of how these steps affect the viability of probiotic cultures during storage and consumption.

Cheese Composition

Cheese varieties can be categorized based on multiple factors:

Milk Source: Cow, goat, sheep, buffalo

Manufacturing Technique: Rennet-based, sour milk cheese, ultrafiltration

Consistency: Extra-hard, hard, semi-hard, semi-soft, soft, fresh

Fat Content: Ranging from double cream to quarter fat

Fermentation Type: Lactic acid, propionic acid, butyric acid

Surface Characteristics: Washed rind, bloomy rind, mold ripened

Interior Features: Eye formation, internal mold development

In addition to variations in texture and flavor, cheese also contains a wide range of bioactive compounds formed during ripening, primarily through fermentation, proteolysis, and lipolysis of lactose, proteins, and fats.

Average Composition of Different Cheese Types

Cheese Type	Water (g/kg)	Protein (g/kg)	Fat (g/kg)	Lactose (g/kg)	Minerals + Vitamins (g/kg)
Fresh Cheese	700	110	80	30	80

Soft Cheese	520	200	220	0	60
Semi-hard Cheese	400	250	270	0	80
Hard Cheese	350	270	310	0	70
Extra-hard Cheese	300	290	330	0	80

Cheese Manufacturing Process

1. Milk Preparation and Standardization

Raw milk is adjusted to ensure the desired ratio of casein to fat, which influences yield and quality.

2. Coagulation

Coagulation is induced by adding rennet (chymosin) or food-grade acid (e.g., lactic acid), causing milk proteins to curdle.

3. Cutting, Draining, and Curd Handling

Once curds are formed, they are cut to facilitate whey expulsion. Depending on the cheese type, processes like heating, stretching, or pressing (e.g., Cheddaring or Mozzarella-style stretching) are applied.

4. Salting and Molding

Salt is either added directly to the curd or applied externally to influence flavor, texture, and microbial stability.

5. Ripening

Cheese undergoes maturation under controlled conditions, leading to microbial, biochemical, and sensory transformations. Ripening methods vary by cheese type: surface mold (e.g., Brie), internal mold (e.g., Roquefort), bacterial smear (e.g., Limburger), or propionic fermentation (e.g., Swiss-type).

Health Benefits of Probiotic-Enriched Cheese

Probiotic cheeses are associated with a broad spectrum of health-promoting effects. These include:

- Alleviation of gastrointestinal disorders
- Antimicrobial properties
- Enhancement of lactose metabolism
- Lowering of serum cholesterol levels
- Modulation of immune responses
- Antimutagenic and anticancer potentials
- Reduction in diarrheal episodes
- Management of inflammatory bowel disease
- Suppression of *Helicobacter pylori* infection

Nutritional Advantages and Functional Components

- **Macronutrients:** Cheese is rich in high-quality protein and saturated fats, providing essential amino acids and fat-soluble vitamins.
- **Bioactive Components:** Contains functional lipids like CLA and phytanic acid. Ripening enhances the formation of peptides with antihypertensive, antioxidative, and anti-inflammatory activities.
- **Micronutrients:** An excellent source of calcium, phosphorus, vitamin A, B-complex vitamins (especially B12 and riboflavin), and sometimes vitamin D.

Potential Health Risks

Despite its benefits, cheese may pose certain health risks due to:

- High levels of saturated fat and sodium
- Accumulation of biogenic amines (e.g., histamine) during ripening
- Possible presence of mycotoxins in mold-ripened varieties

Conclusion

Cheese stands out among dairy products as an effective medium for delivering viable probiotics into the human digestive tract. A viable count of at least 6.0 log cfu/g

is considered sufficient for probiotics to offer their health benefits. Importantly, incorporating probiotics generally does not alter the chemical composition of cheese, though it may impact sensory properties such as flavor and texture. Therefore, probiotic strains must be carefully selected in accordance with the specific cheese type and its processing conditions to ensure both microbial viability and product quality.

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Citrus Peel Essential Oil: DIY Extraction and Everyday Application

ARTICLE ID: 0230

Shashi Kala

Department of Food Science and Post Harvest Technology, Bihar Agricultural University, Sabour, Bhagalpur-813210

Citrus fruits are relished worldwide for their good taste and juiciness. Citrus fruits are not an ample source of nutrients, but the peels are also rich in many bioactive phytochemical compounds, such as essential oils (EOs), which have numerous health benefits. Typically, citrus peels are discarded at home after the fruits are consumed. However, citrus peels are a rich source of EOs, which are sold at high prices in the international market. Cold pressing and solvent extraction methods can be easily utilized at home for oil extraction, offering multiple benefits such as use in confectionery, aromatherapy, personal care, and other household purposes. Home extraction of citrus oils is an eco-friendly and cost-effective approach. Additionally, this approach promotes zero waste or minimizes waste.

Citrus fruits are one of the most important fruit crops grown throughout the world that belongs to the genus citrus and family Rutaceae. Oranges, mandarins, grapefruits, lemons and limes are the main commercialized citrus crops valued for their nutritional

value. Apart from the fresh consumption, one-third of the citrus produced are processed for juices and other value-added products. The peels of citrus are considered as an agro-industrial waste. Citrus peel (CP) is about 40-50% of the fruit weight. However,



citrus peel is a valuable by-product as it is an important source of bioactive components like phenolic compounds, essential oil (EOs), carotenoids and ascorbic acids. CP is rich

source of essential oil and is in great demand in the international markets for its pleasant sensory characteristic aroma and flavour along with having many health benefits. EOs are complex mixture of volatile compounds predominantly terpenes, phenolics and other aromatic substances. These secondary metabolites are responsible for multifaceted roles in plant ecology, including defense against herbivores and pathogens, attraction of pollinators and protection from environmental stressors.

Currently, around 3,000 essential oils (EOs) are known, with 300 of commercial significance.

Extracted from various plant parts—such as leaves, stems, roots, seeds, and flowers—these oils are widely used in fragrance, flavouring, cosmetic, and household industries. Global citrus EO production is about 16,000 tons annually, valued at \$14,000 per ton. Citrus peel essential oils (CPEO) can be easily made at home using a cold-pressed method, offering uses in cooking, aromatherapy, and beauty routines. Instead of discarding citrus peels, individuals can extract CPEO for personal use or potential small business opportunities, promoting sustainability and reducing waste.

Source of EOs

Essential oils are extracted from various plant parts—flowers, leaves, stems, bark, wood, roots, seeds, fruits, rhizomes, and gums—using steam distillation, cold pressing, or solvent extraction. Each plant source provides distinct aromas and chemical profiles. Common essential oils include lavender, eucalyptus, tea tree, peppermint, lemon, and rosemary.

Citrus EOs and its constituent

The chemistry and amount of aromatic oil varies from species to species and also due to climatic conditions. The predominant constituent of citrus oil is limonene (C₁₀H₁₆). Other compounds found in citrus are Myrcene, Linalyl acetate, citral, α -pinene, β -pinene and γ -terpinene. Limonene has a citrus scent and is widely used in perfumes, food flavoring, cleaning products, and aromatherapy. It may offer anti-inflammatory, antioxidant, and anti-cancer benefits.

Methods of Oil Extraction

Plants require different extraction techniques for optimal oil yield. Cold pressing suits citrus peels, while

solvent extraction uses ethanol or alcohol to preserve sensitive compounds. Steam distillation collects oils via steam, supercritical CO₂ extraction retains delicate components with carbon dioxide, and maceration soaks plant material in carrier oil. Cold and hot enfleurage absorb floral scents using fats, which are then washed with alcohol to obtain the oils.

Home Extraction and packaging of Citrus EOs

Homemade CPEO is a rewarding way to utilize citrus fruits completely and incorporate natural, chemical-free alternatives into daily life. A detailed flow chart on two effective methods: cold pressing and solvent extraction, along with important tips have been given (Fig. 1). To get more stronger citrus aroma, increase the soaking/infusion time and quantity of peels. The extracted EOs should be stored in a dark airtight glass bottles at cool and dark place. Always label your container with type and time of oil extraction to track the freshness of your product.

Storage of Citrus EOs

CPEO mostly have a shelf life of six months to one year when properly stored. Always store the EOs at places like cupboards or refrigerator to prevent it from light. So storage in dark bottles with tight seal is recommended. For shelf-life enhancement of citrus oil, add 0.5-1.0 % Vitamin E oil as an antioxidant. This prevent oxidation and degradation of the oil. Storing them in refrigerator also slows down the this process and thus increase the storability of the EOs. Avoid any type of contamination by using clean tools and hands. Following these practices ensures your homemade

citrus oils retain their freshness and effectiveness for optimal use in household applications.

Household application of Citrus EOs

Culinary Enhancements: Homemade citrus oils add bright flavour and aroma to salads, marinades, grilled foods, and desserts.

Aromatherapy and Personal Care: Citrus essential oils work well in diffusers, massage oils, bathwater, and can be added to lotions or masks for skin benefits. Mixed with carrier oils, they hydrate and rejuvenate, help brighten skin, control acne, and offer anti-aging effects, while their scent promotes emotional well-being.

Cleaning Agent and Insect Repellent: Citrus oil naturally cuts grease and grime, makes effective surface cleaners when combined with vinegar or oil, and acts as an eco-friendly insect repellent for surfaces, skin, or clothing.

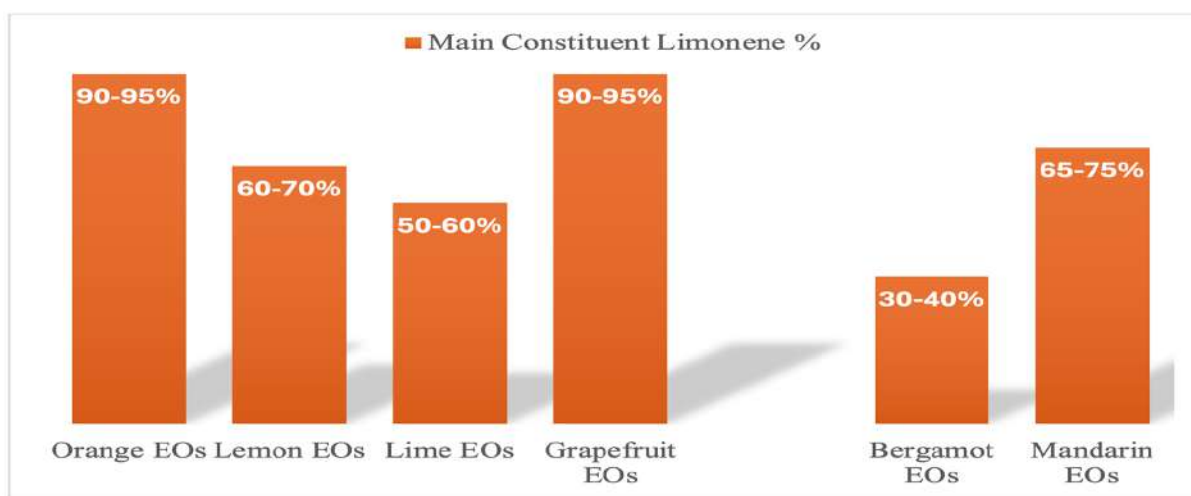
Fire Starters: Their flammability makes citrus oils suitable for lighting lamps and campfires.

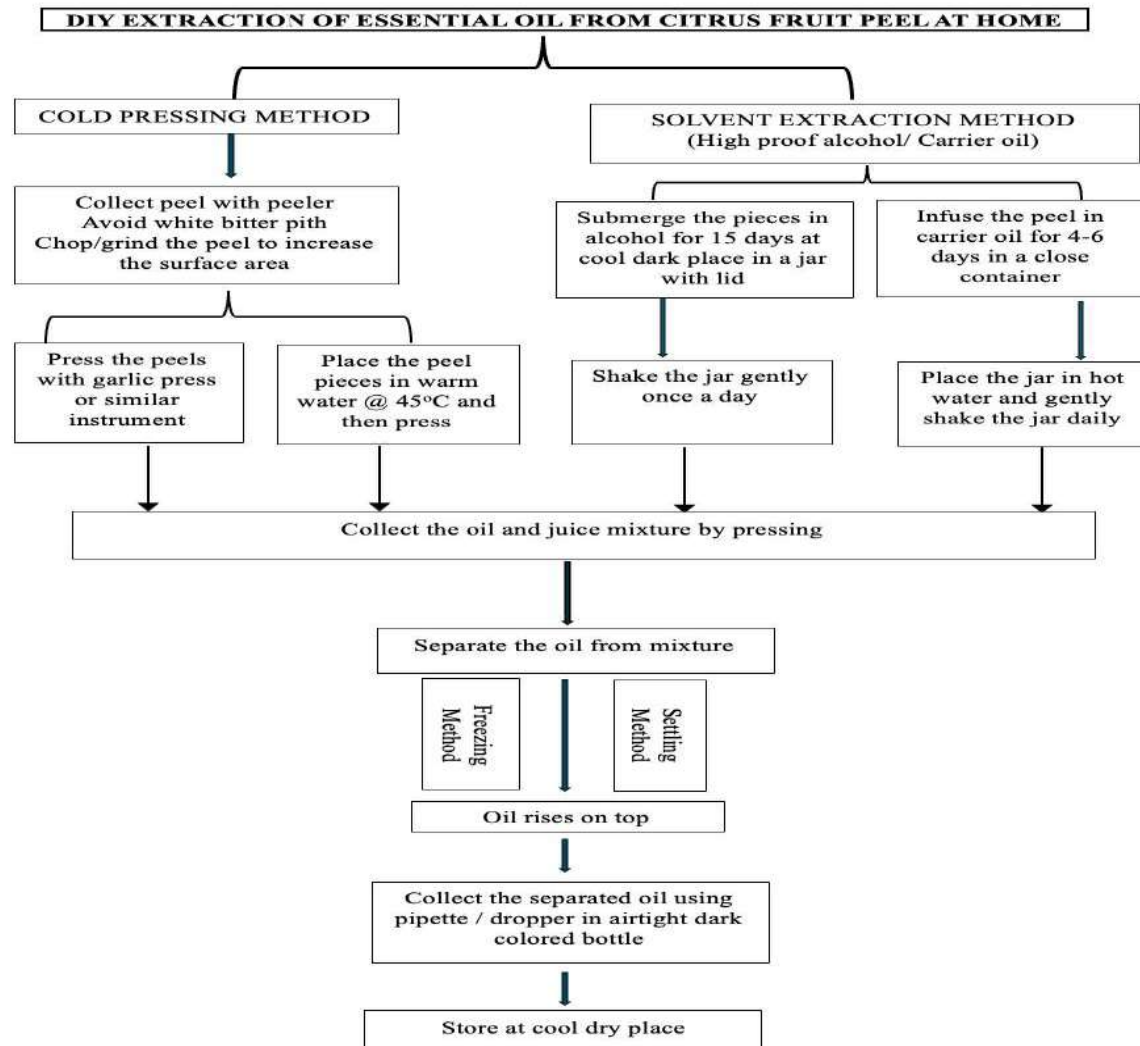
Sustainability and Composting: Citrus essential oils offer antibacterial, antiseptic, and insect-repellent

qualities, serving as sustainable alternatives to chemical products. Leftover material after extraction enriches compost and supports plant health.

Conclusion

Citrus essential oils (CPEO) can be easily extracted at home from oranges, grapefruits, mandarins, lemons, and limes using cold pressing. Recognized as safe (GRAS) when used correctly, these oils offer antibacterial, antiviral, and insect-repellent properties, making them sustainable alternatives to synthetic chemicals. CPEOs are valued in industries like perfumery, cosmetics, food, and pharmaceuticals for their versatility and natural benefits. Quality control and analytical monitoring ensure product reliability. Homemade CPEO can be used in cooking, aromatherapy, personal care, cleaning, and as an insect repellent, but should always be diluted with a carrier oil and patch-tested before skin application due to possible potency and photosensitivity concerns. Use responsibly, considering purity and concentration.





Robotic, Drones and Digital Agricultural Technology in Agri Productivity

ARTICLE ID: 0231

Dinesh Kumar Meena

Department of Horticulture, School of Agricultural Sciences and Technology

Babasaheb Bhimrao Ambedkar University (A Central University) Vidya Vihar, Raebareli Road, Lucknow-
226025, (UP.)- India.

Agriculture, a cornerstone of human civilization, faces unprecedented challenges including climate change, population growth, and resource scarcity. Emerging technologies such as robotics, drones, and digital agriculture offer transformative solutions to enhance productivity, sustainability, and food security. This chapter explores these technologies, their integration into Agri farming, and their alignment with Sustainable

Development Goals (SDGs). It delves into their potential to promote social equity and agricultural sustainability while offering a roadmap for future development.

The agricultural sector is under immense pressure to meet global food demands sustainably. Traditional farming practices often fall short in addressing inefficiencies, environmental concerns, and

labor shortages. Innovations in robotic systems, drone technology, and digital agriculture are paving the way for a paradigm shift in farming practices. These technologies promise precision, efficiency, and scalability, contributing to sustainable and productive



Agri farming.

Robotic, Drone and Digital Agriculture Technologies

Robotic Agriculture

Robotic agriculture involves the use of autonomous machines for various farming activities,

such as planting, harvesting, and weeding. These systems utilize sensors, AI, and machine learning to perform tasks with minimal human intervention, reducing labor dependency and operational costs.

Drone Technology

Drones, or unmanned aerial vehicles (UAVs), are increasingly used for precision agriculture. They provide aerial imaging, monitor crop health, assess soil

conditions, and facilitate precision spraying of fertilizers and pesticides. Equipped with advanced sensors, drones offer real-time data for informed decision-making.

Digital Agriculture

Digital agriculture encompasses the use of data-driven technologies, including IoT (Internet of Things), big data analytics, and cloud computing, to optimize agricultural processes. It integrates smart sensors, weather forecasting, and software platforms for efficient resource management and yield optimization.

Impact of Robotic and Drone Technologies on Agri Productivity

Technology	Impact	Examples of Use Case	Productivity Gains	Barriers
Robots for Harvesting	Reduces crop wastage during harvest	Robotic fruit picking systems	Faster harvesting, less damage	Limited crop compatibility
Drones for Crop Spraying	Uniform chemical application	Spraying rice fields with drones	Reduced chemical use, increased coverage	Battery capacity limitations
IoT-enabled Robotic Systems	Autonomous monitoring and intervention	Robots integrating soil sensors	Enhanced efficiency in field management	High maintenance costs
AI-powered Drones	Real-time pest and weed detection	AI-based imaging drones	Early intervention, improved yield	Dependence on AI algorithms
Autonomous Planting Robots	Precision planting of seeds	Automated row crop planting	Reduced seed wastage	Requires well-prepared land

Why Implement These Technologies in Agri farming?

- 1. **Precision and Efficiency:** Reduces waste and enhances resource utilization.
- 2. **Labor Shortage Mitigation:** Addresses challenges arising from rural-urban migration and aging farming populations.
- 3. **Environmental Conservation:** Minimizes chemical use and promotes sustainable practices.
- 4. **Enhanced Decision-Making:** Provides actionable insights through real-time data analytics.

Importance of Emerging Technologies in Enhancing Agri-Productivity

- 1. **Increased Yield:** Precision farming practices enabled by robotics and drones optimize planting and harvesting, boosting productivity.
- 2. **Cost Efficiency:** Automated systems reduce labor and operational costs.
- 3. **Resource Management:** Digital tools ensure optimal use of water, fertilizers, and pesticides.
- 4. **Risk Mitigation:** Advanced forecasting and monitoring tools help anticipate and manage risks such as pests and weather anomalies.

Interlink of Technologies and Food Security

The integration of robotics, drones, and digital tools plays a critical role in ensuring food security by:

- Enhancing crop yield and quality.
- Reducing post-harvest losses through efficient supply chain management.
- Enabling adaptive farming practices resilient to climate change.

SDGs and Agri farming

These technologies contribute directly to several SDGs:

- **SDG 2 (Zero Hunger):** By increasing agricultural productivity and ensuring food availability.
- **SDG 12 (Responsible Consumption and Production):** Promoting sustainable farming practices.

- **SDG 13 (Climate Action):** Mitigating the impacts of climate change through precision agriculture.

Social Equity and Agricultural Sustainability

Adopting these technologies can:

- **Empower Marginalized Farmers:** Affordable access to advanced tools bridges the technology gap.
- **Promote Gender Equality:** Automation reduces physical labor, enabling greater participation by women.
- **Foster Environmental Stewardship:** Sustainable practices ensure long-term soil fertility and ecosystem health.

Challenges and Future Directions for Robotic, Drone, and Digital Agriculture

Aspect	Current Challenges	Future Opportunities	Impact on Productivity	Potential Solutions
Cost of Technology	High initial investment	Development of affordable solutions	Increases accessibility for farmers	Subsidies for adoption
Skill Requirements	Lack of expertise among farmers	Training programs and farmer education	Improved efficiency with trained users	Partnerships with tech providers
Regulation and Policy	Restricted use of drones in some regions	Clearer policies for agricultural tech	Enhances adoption of drones and robots	Government initiatives
Data Privacy	Concerns about farm data security	Secure and transparent data-sharing platforms	Builds trust among stakeholders	Blockchain for data privacy
Environmental Impact	Battery waste, energy use in robotics	Development of eco-friendly technologies	Reduces carbon footprint in farming	Solar-powered systems

Way Forward

- 1. Policy Support:** Governments must formulate supportive policies for technology adoption.
- 2. Capacity Building:** Training programs for farmers to effectively use these tools.
- 3. Public-Private Partnerships:** Collaboration to develop affordable and scalable solutions.
- 4. Research and Innovation:** Continued R&D to enhance the efficacy and accessibility of these technologies.

- 5. Infrastructure Development:** Investment in digital connectivity and rural infrastructure.

Conclusion

Robotics, drones, and digital agriculture technologies hold immense potential to revolutionize Agri farming. They offer solutions to challenges such as resource inefficiency, labor shortages, and environmental degradation. By fostering food security, promoting social equity, and aligning with global SDGs, these innovations pave the way for a sustainable agricultural future.

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Fortification and Supplementation: Strategies for Addressing Mineral Deficiencies

www.agrirootsmagazine.in

ISSN: 2583-9071

ARTICLE ID: 0232

Tripti Verma¹, Sadhna Singh², Garima Dixit³

¹Assistant Professor, Department of Food and Nutrition, College of Community Science, ANDUA&T, Kumarganj

²Professor, Department of Food and Nutrition, College of Community Science, ANDUA&T, Kumarganj

³Research Scholar, Department of Food and Nutrition, College of Community Science, ANDUA&T, Kumarganj

Mineral fortification is a key public health strategy aimed at preventing micronutrient deficiencies by adding essential vitamins and minerals to commonly consumed foods. Fortification can be categorized into mass fortification, targeted fortification, and market-driven fortification, each addressing specific population needs. Household and biofortification approaches further enhance accessibility and sustainability. Common fortificants include vitamins A, D, E, C, B-complex, iron, iodine, and other minerals, each requiring careful selection to maintain stability, bioavailability, and sensory quality. Fortification offers several advantages, including rapid improvement in nutritional status, low cost, and compatibility with existing dietary patterns.

Supplementation complements fortification by providing concentrated nutrient doses through tablets, syrups, and capsules, especially targeting vulnerable groups like children, adolescents, and pregnant women. National programmes like the Reproductive and Child Health Programme emphasize iron and folic acid supplementation to combat anemia and developmental issues in children and women. Together, fortification and supplementation form an integrated approach to improving population health outcomes.

Mineral Fortification

Food fortification refers to the process of adding one or more essential nutrients to food, regardless of whether the food originally contains these nutrients, to prevent or address nutrient deficiencies in the general



or specific population groups (FAO/WHO, 1994). Other related terms include restoration, which involves replacing essential nutrients lost during manufacturing, storage, or handling, restoring the food's original nutrient levels (FAO/WHO, 1994). Enrichment is often used synonymously with fortification but typically refers to replenishing vitamins and minerals lost during food processing (Hoffpauer and Wright, 1994).

Forms of Food Fortification

Food fortification can be implemented in different ways. It may involve adding essential nutrients to foods that are commonly consumed by the entire population (mass fortification), enriching foods specifically designed for certain groups like young children or displaced individuals (targeted fortification), or allowing food companies to voluntarily add nutrients to products sold in the marketplace (market-driven fortification).

1. Mass Fortification

Mass fortification refers to the process of adding one or more essential micronutrients to staple foods that are regularly consumed by the majority of people, such as milk, cereals, and condiments. Typically, this type of fortification is introduced, regulated, and overseen by government authorities. It is also known as universal fortification.

This approach is most suitable when a large segment of the population is at significant risk of developing micronutrient deficiencies. In some cases, these deficiencies are clearly measurable through low nutrient intake or biological markers, while in other situations, even if clinical deficiencies are not yet

evident, fortification can still provide substantial public health benefits.

2. Targeted Fortification

Targeted fortification focuses on increasing the intake of specific nutrients within particular groups rather than the whole population. This is achieved by fortifying foods specially intended for those groups, such as:

- Complementary foods for infants and toddlers
- Meals provided in school feeding programs
- Special fortified snacks like biscuits for children and pregnant women
- Blended foods or emergency rations for displaced communities or refugees

3. Market-driven fortification

The term “market-driven fortification” is applied to situations whereby a food manufacturer takes a business-oriented initiative to add specific amounts of one or more micronutrients to processed foods. Although voluntary, this type of food fortification usually takes place within government-set regulatory limits. Market-driven fortification can play a positive role in public health by contributing to meeting nutrient requirements and thereby reducing the risk of micronutrient deficiency.

Other type of Fortification

1. Household and community fortification: Efforts are under way in a number of countries to develop and test practical ways of adding micronutrients to foods at the household level, in particular, to complementary foods for young children. In effect, this approach is a combination of supplementation

and fortification, and has been referred to by some as “complementary food supplementation”

2. Biofortification of Staple Foods: The biofortification of staple foods, i.e. the breeding and genetic modification of plants so as to improve their nutrient content and/or absorption is another novel approach that is currently being considered. The potential for plant breeding to increase the micronutrient content of various cereals, legumes and tubers certainly exists; for instance, it is possible to select certain cereals (such as rice) and legumes for their high iron content, various varieties of carrots and sweet potatoes for their favourable β -carotene levels, and maizes for their low phytate content (which improves the absorption of iron and zinc).

Vitamin and Mineral Fortificants

Prudent handling of vitamin and mineral additives in food processing requires a sound understanding of the characteristics of these compounds: their stabilities to various unit operations, solubilities and reactivities with other compounds. Many forms of these nutrients have been developed to render them more suitable for use under a wide range of applications.

Properties of Micronutrient Compounds

1. Vitamin A: In vivo, this vitamin is generally found as the free alcohol or esterified with a fatty acid. The vitamin is available in pure form by chemical synthesis as vitamin A palmitate or the acetate, or recovered from molecularly recovered fish oil. It is a yellowish oily material which may crystallise into needlelike crystals (Parman and Salinard, 1981). Provitamins which are then

converted to their active form, serve not only as nutritive compounds but also as colourants and anti-oxidants. The most common of these is beta-carotene.

In dehydrated foods, vitamin A and provitamin A are highly susceptible to loss by oxidation (Labuza et al., 1978). The extent of this loss depends on the severity of the drying process, protection provided by packaging materials and conditions of storage. Vitamin A in pure form is unstable in the presence of mineral acids but stable in the presence of alkali. Naturally occurring vitamin A is insoluble in water but soluble in oil. In this form the vitamin has limited applicability. Vitamin A fortificants are commercially available in a wide range of forms adapted for use under various conditions. For use in fat or oil based foods such as margarines, oils and dairy products, vitamin A as the acetate or palmitate have been used. They are stabilised with a mixture of phenolic antioxidants or with tocopherols. For mixing with dry products, a dry form of the fortificant was required with the appropriate size and density. Encapsulation of the vitamin in a more hydrophilic coat is commonly practised in order to achieve a more water dispersable product. Two materials used in encapsulation are gum acacia and gelatin. These dry forms of the vitamin are also stabilised using tocopherols or phenolic antioxidants.

2. Vitamin D: The principal forms of the vitamin are D₃ and D₂. They are white, crystalline fat-soluble vitamins, formed by irradiation of the appropriate

sterol followed by purification procedures. These compounds are sensitive to oxygen and light, with the D₃ form of the vitamin being slightly more stable. Trace metals such as Cu and Fe act as pro-oxidants.

As with vitamin A, commercially available forms include fat-soluble crystals for use in high fat content foods, and encapsulated, stabilised versions of the fortificant, suitable for use in dry products to be reconstituted with water. As was stated for vitamin A, at the levels of water activity which exist in dehydrated foods, these fat-soluble vitamins are most susceptible to oxidative loss.

3. Vitamin E: Vitamin E is a slightly viscous, pale-yellow oily liquid obtained from molecular distillation of by-products from vegetable oil refining or by chemical synthesis. The naturally occurring form of the vitamin is the d-isomer. The synthetic compound is a racemic mixture of the d and l isomers. The l-isomer doesn't have the full biological activity of the d-isomer, but due to the stability of the racemic mixture and the ease of purification, the IU of vitamin E has been defined as 1 mg dl-a tocopheryl acetate. The free alcohol form of the vitamin is highly unstable to oxidation and is therefore widely used in foods as an antioxidant to stabilise the lipid component of foods. Esterified forms of the vitamin, commonly the acetate, are much more stable. For this reason, fortificants are usually of this form. As with the other fat soluble vitamins, cold water soluble forms have been produced by encapsulation within a suitable matrix.

4. Vitamins of the B Complex: Vitamin B₁, or thiamine, is a white crystalline solid with a characteristic yeast-like odour and a slight bitter taste. Thiamine is produced by chemical synthesis as the hydrochloride and mononitrate salts. The hydrochloride is soluble to the extent of 50% in water as compared with 2.7% for the mononitrate (Bailey, 1991). Thiamine is one of the most unstable vitamins. Its stability to heat and oxidation is greatest at a pH range of 6 and below. At higher values of pH it becomes increasingly unstable. Thiamine is susceptible to nucleophilic attack, therefore it is degraded by some mineral salts in aqueous foods. Thiamine hydrochloride is the fortificant of choice in cases where dissolution in aqueous media is required. In most other cases the mononitrate is used due to its lower hygroscopicity. Thiamine is also commercially available in a coated form using mono- and di-glycerides of edible fatty acids.

Biotin is a white crystalline powder of low water solubility. It is generally commercially available in diluted form as the physiological requirement for this vitamin is so low. Hoffmann-La Roche sells a 1 % mixture of this vitamin with dicalcium phosphate dihydrate. Biotin is fairly stable to heat, air and light. Vitamin B₂, riboflavin, is of an intense orange colour and low water solubility. A commercially available more water soluble form of this vitamin is the sodium salt of riboflavin 5'-phosphate. Riboflavin is generally stable under most processing conditions, but is

unstable in alkaline medium. It is very sensitive to light, particularly in the presence of ascorbic acid.

Pantothenic acid, is a pale yellow, viscous, hygroscopic liquid which is very unstable. The most commonly used commercially available form is calcium pantothenate. This is a slightly hygroscopic white powder with no smell but a slightly bitter taste. Stability of this compound is greatest at pH values between 5 and 7. Vitamin B₆, pyridoxine, is available commercially as the hydrochloride. Coated forms are also available as with all of the B-vitamins. This vitamin is quite stable to heat and atmospheric oxygen and heat, but degradation is catalysed by metal ions.

Niacin in the form of either nicotinic acid or nicotinamide, can be used in nutrient addition to foods. At very high levels, nicotinic acid has been shown to cause unpleasant side effects such as flushing and 'pins and needles'. This has led to some preference for nicotinamide. Both forms of the vitamin are stable to atmospheric oxygen, heat and light in the dry state as well as in solution.

Cyanocobalamin, the most important compound with vitamin B₁₂ activity, is commercially available as a crystalline, dark red, hygroscopic powder. Human requirements for this vitamin are very low and it is commonly sold highly diluted by a carrier. In the preparations sold by Hofmann-La Roche, for instance, it can be purchased diluted with mannitol or a mixture containing modified starches, citrate, citric acid, benzoate, sorbic acid and silicon dioxide. The selection of preparation depends, of course, on the

end use. In solution it is most stable between pH values 4-7. It is unstable to oxidising and reducing agents and exposure to sunlight, but is fairly stable to heat (Bailey, 1991).

Folic acid is a yellow-orange, odourless, tasteless crystalline substance. It is moderately stable to heat and atmospheric oxygen. In neutral solution it is quite stable, but instability increases with a shift in pH in either direction. Folic acid is unstable to heat, light, sunlight, oxidising and reducing agents.

5. Vitamin C: Vitamin C or ascorbic acid is an odourless, white, crystalline compound which is stable in its dry form. Due to its high water solubility, losses due to leaching can be a problem in some processing procedures. Ascorbic acid is readily oxidised. In dehydrated citrus juices the degradation is dependant on both temperature and water activity. Other factors as well can influence the degradation behaviour of vitamin C, these include salt and sugar concentration, pH, oxygen, metal catalysts and ratio of ascorbic: dehydroascorbic acid.

Vitamin C addition to foods is commonly practised for reasons other than fortification. Commercially available forms of this vitamin include the free acid and the sodium and calcium salts of these, in powder as well as crystalline or granular form. For mixing with dry products, particle size and density are of course important considerations. A fat coated form of ascorbic acid is also available for enrichment purposes. Ascorbylpalmitate, is a form of the vitamin used for

purposes other than fortification. It is used as an antioxidant in fats and oils and has also emulsifying properties (Anon. 1985). Other areas of food processing for which vitamin C has application are the prevention of browning in fresh and canned fruit and vegetables, acidification, curing of meat and prevention of haze formation in brewed products (Borenstein, 1987).

6. Iron Fortificants: Iron compounds used in food fortification are commonly classified according to their solubility. Selection of an appropriate iron fortificant for any given application is based on the following criteria: organoleptic considerations, bioavailability, cost and safety (Hurrell and Cook, 1990).

The colour of iron compounds is often a critical factor when fortifying light coloured foods. For example white iron, ferric orthophosphate, is often the fortificant of choice in the enrichment of rice. The use of more soluble iron compounds often leads to the development of off-colours and off-flavours due to reactions with other components of the food material. Infant cereals have been found to turn grey or green on addition of ferrous sulphate. Off-flavours can be the result of lipid oxidation catalysed by iron. The iron compounds themselves may contribute to a metallic flavour. Some of these undesirable interactions with the food matrix can be avoided by coating the fortificant with hydrogenated oils or ethyl cellulose.

Bioavailability of iron compounds is normally stated relative to a ferrous sulphate standard. The highly water soluble iron compounds have superior

bioavailability. Bioavailability of the insoluble or very poorly soluble iron compounds can be improved by reducing particle size. Unfortunately this is accompanied by increased reactivity in deteriorative processes.

Sodium iron EDTA is less well absorbed than ferrous sulphate from foods which contain few inhibitors to absorption. In the presence of these inhibitors, however, the EDTA complex is better absorbed. Sodium iron EDTA also participates to a lesser extent in deteriorative reactions. The use of this compound reduces the problem of precipitate formation in foods such as fish sauces and tea. The use of this compound is not advised in developed countries where the population already receives close to the recommended acceptable daily intake of EDTA (Hurrell and Cook, 1990).

The problem of low bioavailability of some of the less reactive forms of iron is often circumvented by the use of absorption enhancers added along with the fortificant. Examples of such enhancers are ascorbic acid, sodium acid sulphate and orthophosphoric acid.

7. Iodine Compounds: The most commonly used compounds in the iodisation of foods are the iodides and iodates of sodium and potassium. These are the additives allowed by Codex Alimentarius in the iodisation of salt. The iodide compounds (Bauernfeind, 1991) are cheaper, more soluble and have a higher iodine content (so that less is needed to achieve the same level of iodisation) than the corresponding iodates. Iodates are more stable under conditions of high moisture, high ambient

temperature, sunlight, aeration and the presence of impurities.

The use of iodate is therefore recommended for use in developing countries. Potassium iodide is well suited in cases where the salt is dry, free from impurities and has a slightly alkaline pH. Otherwise the iodide may be oxidised to molecular iodine and lost through evaporation. If excess water is present the iodide may be separated from the salt in the water film (FAO/WHO, 1991). Loss of iodide can be reduced through the addition of stabilisers such as 0.1% sodium thiosulphate and 0.1% calcium hydroxide combined or 0.04% dextrose and 0.006% sodium bicarbonate (Kuhajek and Fiedelman, 1973). Calcium salts have been used with some report of off-flavour due to the calcium ions (Kuhajek and Fiedelman, 1973). The calcium compound is also much less water soluble than the sodium and potassium compounds and this further limits its applicability.

8. Other Mineral Additives: A range of mineral salts are available for fortification with Ca, Mg, P, Zn, Cu and Mn. Prudent selection of mineral compounds is based largely on consideration of mineral reactivity and solubility of the salt. The requirements of the fortificant vary according to the nature of the food product and its end use. To overcome problems of flavour, texture and colour deterioration due to addition of minerals, some companies have engineered new fortificant preparations which generally involve the use of stabilisers and emulsifiers to maintain the mineral in solution (Anon. 1986).

Advantages of Mineral Fortification

- Potentially rapid improvements in micronutrient status of population.
- Reasonable cost, especially with existing technology and local distribution networks.
- Requires no changes in existing food patterns or in individual compliance.
- Fortified food consumed in adequate amounts by target population.
- Fortificants that are stable and well absorbed, but do not affect sensory properties of foods.
- Preferably, centrally processed food vehicles.
- Government and food industry partnership.

Supplementation

- Food supplements are concentrated sources of nutrients or other substances with a nutritional or physiological effect, with the purpose of supplementing the normal diet.
- Food supplements are highly concentrated vitamins and minerals produced by pharmaceutical manufacturers in the form of capsules, tablets or injections and administered as part of health care or specific nutrition campaigns.
- Food supplements can be in the form of pills, tablets, capsules or liquids in measured doses.
- Supplements may be taken in order to correct nutritional deficiencies or maintain an adequate intake of certain nutrients. However, in some cases an excessive intake of vitamins and minerals can be harmful to health. Therefore maximum levels are necessary to ensure their safe use in food supplements.

- Reaching out to vulnerable groups (particularly children and women of childbearing age) with vitamin and mineral supplements in the form of tablets, capsules and syrups.
- The cost can be as low as a few cents per person per year.
- Under Reproductive and Child Health Programme : Young children and adolescent girls are given iron and folic acid.
- Children 6-24 months old are at the greatest risk of the irreversible long term consequences of iron deficiency namely impaired physical and mental development.
- They are given 20mg elemental iron and 100 microgram of folic acid in syrup form. Children below 5 years are given 20mg of elemental iron and 100 microgram of folic acid.
- Adolescent girls on attaining menarche should consume weekly dosage of IFA tablet containing 100 mg elemental iron and 500 microgram of folic acid.
- All pregnant mothers are given 60mg of elemental iron and 500 microgram of folic acid. Low birth weight infants need iron supplementation from the age of 2 months.

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How to grow Cluster beans?

ARTICLE ID: 0233

Himani Katre

Faculty of Agriculture, Index group of institutions Indore

MSc Horticulture (Vegetable science), DCA, BEd.

www.agrirootsmagazine.in

ISSN: 2583-9071

Guar (*Cyamopsis tetragonolobus*) beans also known as Cluster bean is an important legume crop. Guar beans mostly grown on dry and semi arid zones of India & Pakistan. Cluster bean is one of the vegetable crop and also a drought tolerant typical legume vegetable, which is grown for vegetable and gum extract purposes. In green manuring we use this vegetable crop. It is locally known as guar. Among pulses crops guar bean has a special contribution. In India it is grown in majorly Rajasthan, Gujarat, Haryana, Uttar Pradesh but Rajasthan stands first in the area and production of Cluster bean. The crop also known as for gum produce which is exported in foreign countries. Cluster bean seeds contain 18-19 % protein, 32-35 % fibre and 30-32 % gum which is present in endosperm.

Cluster bean which is also known as guar bean mainly belongs to West Africa and India region. Cluster bean contains mucilaginous substance in seed is known as glectomannas. The guar bean seeds contain

68-70 % glectomannas polysaccharide also known as guar gum, Using in textile industries, paper industries, cosmetic and oil industries. Young plants have hydrocyanic acid (HCN) which causes toxicity in

animals. It's a tropical plant which requires warm climate. It is not only vital food but also has beneficial industries, this crop used in diabetic therapy. If we talk about the traditional purpose, the main use of cluster bean plants was as a green manure



and soil conserving crop. In Rajasthan it's mainly used for vegetable purpose. Cluster bean is a less disease and pest resistant crop, it requires less water for irrigation also a low cost crop with high input.

Climate and Soil

Climate

Cluster bean is well suited for warm, arid and semi arid zones. It's a warm season crop and short day plant.

Temperature

Optimum temperature required 25-35°C

Soil

Well drained, sandy loamy, sandy clay loam soil

Soil pH

ideal pH for crop is 6.5 - 7

Land preparation

After harvesting of Rabi crop deep ploughing should be done as a field preparation, cluster bean is well drained sandy loamy, sandy clay loam soil. Before sowing land should be prepared properly. 1-2 ploughing and harrowing can be done because properly leveled field is required for good drainage system.

Seed and Sowing

1. Seed rate: 30-40 kg/ha.

2. Sowing time: Rainy season the crop is sown in the first week of July to last week of July

Summer season: February to March

Row to Row spacing: 45×45 cm

Plant to plant Spacing: 10 to 15 cm

Seed treatment - Seed treatment with Carbendazim 1g per kg and Thiram 2 g per kg of seeds. Seeds can be treated 3-4 Days before sowing.

Fertilizer application: proper nutrient management is play major role to minimize crop losses. Before sowing can be apply well rotten organic compost to improve soil fertility and microbial activity in soil, NPK is essential nutrients for guar bean plants, always apply fertilizers at the recommendation rates, do not use of access nitrogen fertilizer because cluster bean is sensitive for excessive nitrogen.

Irrigation: Cluster bean is warm season crop, so it's required regular intervals irrigation, for good production one irrigation can be done in the stage of flowering and pod formation if crop suffer moisture

stress. Crop cannot tolerate water logging condition therefore proper drainage is required in the field.

Weed management: Weed competition can significantly reduce cluster bean yield. Two manual weeding required in this crop

- First at 20 to 27 days
- Second at 40 DAS (day after sowing)

Mulching or the use of post and pre-emergence herbicides can help control weed in the field. Sometimes due to non availability of labour, chemical weed control can be done. Care should be taken to avoid damaging the Guar bean plants during weeding operations.

Pest and Disease Management: Integrated Pest Management (IPM) practices can be done to protect the crop from pest and diseases, for insect use well decompose FYM and seed treatment and for controlling diseases use resistant/tolerant varieties and certified seeds

- **Common Pest:** Aphid, whitefly, sucking insects and termites.
- **Diseases:** Powdery mildew, phytophthora, pod rot and rust.

Harvesting and Yield: Harvesting can be done in the basic of maturity index, for grain purpose crop, Harvesting is done when leaves become dry and pod turning into brown upto 50 % and dry. Threshing done by manually or thressure. For fodder crop cut the leaves when the crop at flowering stage.

- **Green Pod:** 40-45 DAS, harvest tender pod for curry purpose, yield upto 60 to 80 q/ha

- **Seeds:** Harvest when plants dry and pod turn brown for gum extraction, yield upto 10 to 12 q/ha

Advantages

- Atmospheric Nitrogen fixation is done by cluster bean plants
- Green pod use as vegetable
- Nutrient enrich fodder crop for livestock and cattle
- Increase soil fertility and reduce soil erosion
- Gum can be produce from seeds of guar
- It' is also use in green manure

Conclusion

Cluster bean cultivation steps that, when followed can be successfully lead to a sustainable cultivation process. From selecting the right varieties, best land preparation, irrigation, nutrient management, pest and disease management and harvesting. Cluster bean requires proper attention and care it's low cost with high beneficiary, proper irrigation can enhance the yield and quality of crop. Beneficial for both food consumption and industrial applications.

From Asana to Aahar: The Combined Power of Yoga and Diet in Lifestyle Medicine

www.agrirootsmagazine.in

ISSN: 2583-9071

ARTICLE ID: 0234

Priya Pandey¹, R.N. Kewat², Sheetanu Singh¹, Garima Dixit³

¹Research Scholar, Department of Biochemistry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya

²Professor, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya

³Research Scholar, Department of Food and Nutrition, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya

This chapter explores the intertwined relationship between yoga, diet, and holistic health, emphasizing their collective role in

preventing and managing modern lifestyle disorders.

Rooted in ancient Indian traditions, yoga is portrayed as a comprehensive discipline that harmonizes the mind and body through ethical practices (Yama and Niyama), physical postures (Asanas), breath

control (Pranayama), sensory withdrawal (Pratyahara), concentration (Dharana), meditation (Dhyana), and

ultimate absorption (Samadhi). The chapter also delves into Ayurvedic dietary principles, highlighting the impact of wholesome, sattvic food on physical vitality and mental clarity. Scientific findings are integrated to support the efficacy of yoga and diet therapy in

addressing conditions such as hypertension, cardiovascular diseases, stress, anxiety, and depression. Additionally, it sheds light on the



biochemical influence of food on mood and cognition, reinforcing the age-old belief that both diet and yoga can profoundly shape human behavior and emotional well-being.

Yoga is an ancient discipline centered on performing physical postures (asanas) to cultivate balance between the mind and body. By mastering the mind, we return to our true nature; as expressed in “Tada Drashtuh Svarupe avasthanam.” (Naragatti,2020) India is renowned for its deep-rooted yoga traditions, and with ongoing scientific advancements, the therapeutic value of yoga is gaining wider acknowledgment.

Practicing yoga consistently contributes to better health, sharpens focus, improves strength and flexibility, and brings tranquility to both body and mind. Regular engagement in yoga can lead to transformative outcomes, including a more positive outlook on life, increased self-awareness, and a renewed enthusiasm for living with true joy. (Pandit *et. al.*,2023) Over the past several decades, extensive research into yoga therapy has highlighted its value as a supportive approach alongside conventional medical treatment, as well as its role in long-term rehabilitation. Emphasizing the adage "prevention is better than cure," yoga has emerged as a key practice for disease prevention. As a result, many health clubs now incorporate yoga into their regular programs, with some individuals attending these facilities specifically to participate in yoga sessions. (Naragatti,2020). There is a strong connection between yoga and diet. Proper nutrition is essential for maintaining health, managing disease symptoms, and potentially minimizing the need for medications. Ayurveda emphasizes the importance of a wholesome diet, which is believed to promote long life and robust health. According to Ayurvedic principles, a wholesome diet is one that is agreeable, nourishing, and supportive of both mental and physical well-being. In contrast, a diet that does not suit the mind and body is regarded as unwholesome (Pandit *et. al.*,2023)

The Rise of Lifestyle Disorders

The kind of diet a person follows has a direct impact on their behavior. As noted, "nutrients, whether consumed as part of food or in isolated form, can

change the brain's chemical makeup and thereby influence its functions." Numerous studies have explored how different food components affect brain health. For instance, diets rich in certain amino acids can help manage mood disorders like depression, while excessive intake of sugar, salt, or fat increases the risk of conditions such as hypertension, diabetes, and obesity. Consuming fresh fruits and vegetables, which are high in nutrients and antioxidants, may improve mood by influencing brain serotonin levels. Conversely, overeating foods high in saturated fats and sugars can impair memory. Additionally, rock salt, recommended during fasting, is rich in potassium and supports mental calmness. Overall, the chemical composition and purity of one's diet play a crucial role in mental well-being, a concept also reflected in ancient texts like the Chandogya Upanishad, which links pure food to mental clarity and liberation from emotional burdens.(Bansal,2024)

Overview of Yoga and Diet Therapy

Yoga practice is associated with increased fruit and vegetable intake, healthier dietary patterns, and more mindful approaches to eating. The use of meditation to boost mindfulness can aid in curbing binge-eating tendencies. Among those with diabetes, mindful eating has been shown to support improved nutrition, moderate weight loss, and better glycemic management (Raveendran *et.al.*,2018)

Types of Yoga and Their Benefits

There are many different forms of yogic practices, each offering unique benefits

Yama: The concept of Yama encompasses five ethical principles that guide moral conduct. These include

Ahimsa, which emphasizes non-violence and encourages individuals to avoid causing harm to others through actions, words, or even thoughts. Satya refers to truthfulness and the importance of honesty and sincerity in all interactions. Asteya means non-stealing, which involves refraining from taking anything that does not belong to oneself, extending to honesty in all aspects of behavior. Brahmacharya signifies sexual restraint or dedication to spiritual pursuits. Lastly, Aparigraha promotes an attitude of non-possessiveness, encouraging individuals to avoid greed and the desire to hoard material possessions.

Niyama: The Niyamas consist of five personal observances that foster self-discipline and personal growth. Shaucha emphasizes both internal and external purity, encouraging cleanliness of the body and mind. Santosha is the practice of contentment, promoting satisfaction and helping to overcome greed and envy. Tapah refers to austerity and self-discipline, encompassing both physical and mental endurance, and includes rigorous yogic practices that cultivate inner purity. Svadhyaya involves the study of sacred texts and self-reflection, inspiring deep contemplation on spiritual questions such as one's purpose and direction in life. Ishvarapranidhana is the practice of surrendering to a higher power or the Supreme Self.

Asana: Asana involves performing physical poses designed to promote balance and steadiness in both the body and the mind.

Pranayama: Pranayama involves using specific breathing exercises to control and steady the breath, slowing it down and making it more subtle, which

promotes a sense of equilibrium and unity between the mind and body.

Pratyahara: It means purposefully turning the senses inward, preventing them from being influenced by external stimuli or distractions.

Dharana: refers to sustaining attention on one chosen object, developing unwavering and unified concentration.

Dhyana: Dhyāna is the continuous and unbroken flow of attention toward one point of focus during meditation.

Samadhi: represents the complete absorption into pure awareness, where the differences between who sees, what is seen, and the act of seeing disappear (De *et.al.*,2017)

The Science of Aahar (Diet)

A wholesome diet, considered essential in Ayurveda, offers numerous benefits like increased energy, stronger immunity, better skin and vocal health, and sharper intellect. It is also believed to enhance the effectiveness of treatments and help balance the body's internal systems for overall well-being. (Pandit *et. al.*,2023)

Principles of Yogic Diet

A sattvic or yogic diet emphasizes foods believed in Ayurveda and Yoga to promote mental clarity and balance, such as fresh fruits, vegetables, grains, legumes, nuts, and dairy products like fresh milk and ghee. Foods are classified as sattvic (pure and beneficial), rajasic (stimulating), or tamasic (harmful or stale), with leftovers and foods involving harm to living beings considered tamasic. The purest sattvic foods are those obtained without causing harm, like

fruit that has fallen naturally from a tree (Parashar *et.al.*,2015)

How Yoga and Diet Work Together

A balanced diet supports both body and mind, making yoga more beneficial. Ayurveda explains how proper nutrition, combined with yoga, leads to greater energy and well-being. This combination is effective for improving health, boosting immunity, and increasing longevity, serving as essential guides for disease prevention and health preservation, even though their significance has diminished with the rise of modern science. .(Pandit *et. al.*,2023)

Hypertension and Cardiovascular Diseases

In India, conditions like high blood pressure, abnormal cholesterol, and elevated blood sugar are major contributors to cardiovascular disease (CVD). CVD risk factors are classified as modifiable (such as high BP, cholesterol, smoking, and obesity) and nonmodifiable (like age, gender, ethnicity, and family history). Managing CVD starts with assessing an individual's risk using tools like QRISK3, which considers a wide range of factors. While lifestyle changes such as regular exercise, healthy eating, and weight control have reduced CVD deaths, especially in older adults, more efforts are needed for those under 65. Regular yoga practice has been shown to lower risk factors like high blood pressure and cholesterol, making it a valuable tool for both preventing and managing CVD.(Kacker *et.al.*,2023)

Stress, Anxiety, and Depression: Scientific studies have shown that yoga has anti-stress benefits, helping to reduce stress levels dance therapy. According to the

Agency for Healthcare Research and Quality, yoga is effective in lowering stress, which is important since stress is known to weaken the immune system. Numerous studies indicate that practicing yoga lowers anxiety and stress, enhances mood and physical health, and helps manage depression, including in caregivers of dementia patients. While yoga and similar mind-body therapies are effective compared to doing nothing, their benefits are less clear when measured against other established treatments.(Bhavani *et.al.*, 2014)

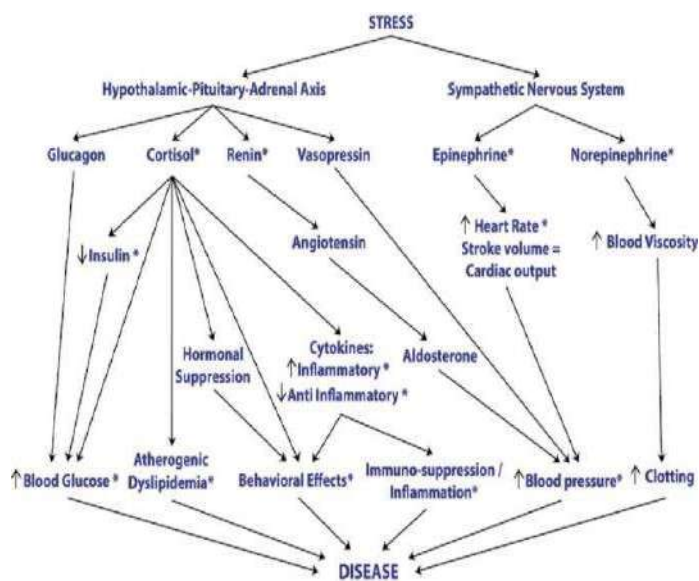


Figure: Impact Of Stress On Hypothalamic–Pituitary–Adrenal (Hpa) Axis And Sympathetic Nervous System

Conclusion

Yoga and diet are deeply connected systems that promote optimal health by fostering balance across the physical, mental, and spiritual dimensions of life. When practiced regularly and mindfully, yoga enhances bodily flexibility, mental focus, and emotional resilience. Meanwhile, an Ayurvedic and sattvic approach to diet nurtures inner purity, supports disease prevention, and complements

therapeutic interventions. Together, yoga and a conscious dietary lifestyle offer a sustainable, preventive approach to combating lifestyle-related disorders, including cardiovascular issues and psychological stress. As scientific research

continues to validate these ancient practices, integrating them into modern healthcare and daily life becomes increasingly essential for cultivating long-term wellness and vitality.

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Blooming Success: The Benefits of Hydroponics in Floriculture

ARTICLE ID: 0235

Mane Priyanka

PhD Scholar (Floriculture and Landscaping), Sri Konda Laxman Telangana Horticulture University, Mulugu

With its many advantages and expansion prospects, hydroponics is transforming the floriculture sector. Hydroponics allows growers to grow high-quality flowers with better yields and less of an impact on the environment by utilising nutrient-rich solutions instead of soil. Compared to traditional soil-based systems, these methods have a number of benefits, such as increased crop yields, quicker growth rates, lower water usage, and the capacity to cultivate plants on arable land. Plants grown hydroponically are grown under regulated conditions where nutrients are dissolved in water and sent straight to the roots of the plants. This technique reduces the risk of soil-borne illnesses and pests, resulting in healthier plants and less dependence on chemicals. It also enables accurate monitoring and adjustment of nutrient levels, pH balance and other environmental parameters, resulting in optimal plant development and health.



Hydroponics

With or without the use of inert media, such as gravel, vermiculite, rockwool, peat moss, sawdust, coir dust, coconut fibre, etc., to offer mechanical support, plants are grown in nutrient solutions that apply all the nutrients required for optimal plant growth.

Benefits of Hydroponics

Increased Crop Yields: Hydroponics can increase crop yields while reducing water consumption and environmental impact.

Year-Round Crop

Production: By controlling the growing conditions, hydroponics enables farmers to grow crops regardless of external seasonal variations.

Water Conservation: Hydroponics reduces water waste associated with traditional irrigation systems, making it a sustainable solution for urban agriculture.

Improved Crop Quality

Hydroponics enables farmers to control the growing conditions, resulting in improved crop quality and reduced defects.

Reduced Water Consumption

Hydroponics reduces water waste and making it a sustainable solution for urban agriculture.

Increased Efficiency

Hydroponics enables farmers to optimize crop growth and reduce labor costs, resulting in increased efficiency and profitability.

Enhanced Coloration and Fragrance

Hydroponic systems can optimize nutrient concentration, light spectrum and photoperiod to enhance coloration and fragrance of flowers.

Uniform Size and Shape

It promotes uniform growth patterns, resulting in consistent shape and size of flowers, making them more aesthetically appealing and marketable.

Faster Growth Rates

Hydroponics can fasten the flower growth by upto 50%, allowing for quicker turnover and more frequent harvests.

Sustainable agriculture: Hydroponics reduces land and water usage, aligning with the principles of sustainable agriculture

Examples of flowers that can be suitable for

Hydroponic culture

Roses	Amaryllis	Hyacinth
Carnation	Iris	Pansy
Chrysanthemum	Daffodil	Marigold
Gerbera	Freesia	Snapdragon
Orchids	Peace Lily	Alstroemeria
Tulips	Gaillardia	Nasturtiums
Begonias	Geraniums	African violets

Different Methods

Nutrient Film Technique (NFT)

Plants are grown in long, narrow channels with a continuous flow of nutrient rich water. This method is well suited for Orchids.

Drip System

Nutrient solution is delivered directly to the base of each plant, making it highly efficient. This method is highly efficient and suitable for a wide range of flower varieties including roses, gerbera and carnations.

Ebb and Flow System

The growing area is flooded with nutrient solution and then drained back into the reservoir, providing plants with a consistent supply of nutrients. This method is mostly suitable for begonias and geraniums.

Aeroponics

Plant roots are suspended in the air and periodically misted with a nutrient solution, promoting rapid growth and increased nutrient absorption efficiency. This method is mostly suitable for delicate and high value ornamental crops.

Deep Water Culture (DWC)

Plants are grown in a container with a reservoir of nutrient rich water and roots are suspended in the water.

Monitor and adjust the environmental factors

pH level

Slightly acidic to neutral pH range (5.5 to 6.5)

Temperature

Typically maintain the temperature 18-25°C are suitable for most of the floricultural crops

Humidity

Generally 50-70% suitable Lightening Provide adequate artificial lighting such as LED or grow lights

to support photosynthesis and plant growth. Duration and intensity depend on the plant's light requirements.

Monitor Nutrient Levels

Regularly test the nutrient solution for pH, EC and nutrient concentration.

Applications of Hydroponics

Hydroponics is being used in urban agriculture to provide fresh produce to local communities

Cut Flower Production

It can be used to grow high quality cut flowers such as roses, gerbera and carnations.

Potted Plant Production

It can be used to grow potted plants such as African violets and begonias.

Green House Production

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Hydroponics can be used in green houses to grow a wide range of flowers, including orchids and gerberas with precise control over temperature, humidity and light.

Urban Agriculture

Hydroponics can be used in urban areas to grow flowers, providing fresh produce to local communities and reducing costs.

Conclusion

Hydroponic floriculture is a blooming success, offering numerous benefits and opportunities for growth. By using hydroponics, farmers can increase crop yields, conserve water, reduce the environmental effect and produce high-quality flowers year-round.

Kitchen Gardens: A Small Step Towards a Healthy Future

www.agrirootsmagazine.in

ISSN: 2583-9071

ARTICLE ID: 0236

Shobhit Sharma¹, Pavitra Dev², Krishan Choudhary¹, Sonit Kumar³

¹*Research Scholar, Department of Horticulture, Chaudhary Charan Singh University, Campus Meerut, Uttar Pradesh India 250004.

²Assistant Professor, Department of Horticulture, Chaudhary Charan Singh University, Campus Meerut, Uttar Pradesh India 250004.

³Research Scholar, Department of Horticulture, Ch. Chhotu Ram (PG) College, Muzaffarnagar (U.P)

Kitchen gardening, also known as home gardening or backyard gardening, refers to the practice of growing vegetables, fruits, herbs, and other edible plants in or around the house.

The main purpose of growing vegetables in a kitchen garden is to provide fresh and nutritious vegetables to the family every day. For this, some vegetables should be available throughout the

year according to the season. Kitchen gardening also encourages the recycling of household organic waste, especially when compost pits or bins are used to convert kitchen scraps into natural manures, thus reducing environmental pollution. In recent years, especially after covid-19 period kitchen gardening has gained popularity as people realize that growing vegetables at home is just as enjoyable and valuable as

planting flowers or cacti. It offers fresh, chemical-free produce and the joy of growing one's own food.

In addition to its physical and economic benefits, kitchen gardening also offers emotional and psychological advantages. Apart from entertainment, kitchen gardening is also a great means of exercise. It is a good way for every member of the family, young and old, to spend their free time. One or two hours spent in the home

garden in the morning and evening is healthy for the body.

The expenditure on homegrown vegetables reduces the cost of buying vegetables from the market and on transportation. In comparison, the cost of growing vegetables at home is a fraction of that amount. In this way, people of all classes can grow more vegetables at a lower cost in their kitchen garden. Vegetables



available in the market often contain pesticide residues that are harmful to health. In contrast, vegetables grown at home are clean, fresh, and free from the dirt and chemical contamination commonly found in market produce.

Role of kitchen gardening

1. Chemical Free-Produce

Kitchen gardening produces fresh, chemical-free fruits and vegetables, making it a healthy and consistent source of daily nourishment for the family. Individuals who cultivate their own food can avoid the toxic pesticides and chemicals which are generally used in industrial farming. It also improves quality, flavor, and safety, while encouraging a more natural and environmentally friendly lifestyle.

2. Enhancing Food Security

Kitchen gardening is crucial to ensuring household food security. It enables easy access to fresh and secure food, decreasing reliance on the market. Families can grow seasonal vegetables and fruits, ensuring availability even amid shortages or inflation.

3. Nutritional Support

A home garden can help to eat a more balanced diet. It promotes the consumption of a varied range of fresh food high in vitamins, minerals, and antioxidants. Leafy greens, tomatoes, carrots, and herbs can help promote dietary diversity and combat malnutrition, particularly in children and aged member of family.

4. Waste Management

Kitchen gardening encourages ecologically conscious activities by utilizing natural fertilizers such as kitchen waste and organic compost. Composting vegetable peels, fruit scraps, and used tea leaves enriches soil

while reducing domestic waste and promoting sustainability.

5. Educational Value

Gardening activities provide wonderful educational opportunities for both children and adults. It teaches patience, responsibility, and an understanding of plant biology and ecology. It can also be used in educational programs to raise environmental awareness among students.

6. Therapeutic Benefits

Gardening offers psychological benefits. It reduces stress, improves mood, and promotes physical activity. During the COVID-19 pandemic, many people chose gardening as a hobby to improve their mental health and keep them engaged at home.

7. Cost-Effective Living

Growing food at home lowers grocery costs. Even a small balcony garden may produce enough herbs, chiles, and leafy greens for daily consumption, making kitchen gardening an affordable alternative for many families.

8. Environmental IMPACT

Home gardens contribute to biodiversity conservation. They provide habitat for pollinators such as bees and butterflies and contribute to a lower carbon footprint by eliminating the demand for packaged and transported food.

9. Urban Greening And Aesthetic Value

In cities with limited green space, kitchen gardens improve the visual appeal of balconies, rooftops, and backyards. They also assist in minimize urban heat and enhancing the air quality.

Getting Started With Kitchen Gardening

Space utilization: The kitchen should be garden situated in the south direction because it receives

maximum sunlight throughout the day, which is essential for the healthy growth of most vegetables and herbs. Use balconies, terraces, windowsills, or backyard patches. First, avoid mixing different types of vegetables in the same area. This makes it easier to prepare the soil each time you plant new seeds. Second, sunlight is very important, so choose a spot that gets at least 7 to 8 hours of direct sunlight every day. third, vegetables that grow as vines, like bitter melon, bottle melon, and other cucurbits, should be planted separately from those that don't climb. lastly, these vine vegetables should be grown near some support, like a wall or sticks, so they can climb and grow properly.

Soil and compost: For successful kitchen gardening, it is important to use a light weight, well-draining soil mixer for kitchen gardening. Combine garden soil with vermicompost, FYM (farmyard manure), and cocopeat or sand is better essential for aeration and moisture retention. Vermicompost and FYM enrich the soil with nutrients, while cocopeat keeps it light ideal for pots and containers this mix supports healthy, chemical-free plant growth. Bio- enhancer such as sea weed extract, panchagavya, Jeevamrut, etc also very effective not only for enhance nutrient status but also protect from insect pest and disease.

Selection of fruit and vegetables: For kitchen gardening vegetables may be chose based on choice of family. Keep in mind the season of the vegetables as some vegetables grow well during winter and while others are summer lovers.

- **Winter vegetables:** Winter vegetables include spinach, cabbage, radish, pea, carrot, cauliflower,

turnip, onion, sugar beet, coriander, salad leaves, and garlic, among others.

- **Summer vegetables:** Some summer vegetables are cucurbits, chiles, bitter melon, bottle melon, tomato, eggplant, okra, etc
- **Fruits:** Papaya, strawberry, pineapple, citrus etc

Watering and sunlight: Effective watering kitchen garden require knowledgeable of the properties timing and method to ensure optimal plant growth and development. The best times of water are early in the morning or late in afternoon to reduce evaporation. Watering at least once a week is essential to promotes robust root development. However, it also depends on the weather condition of particular area, in a kitchen garden, sunlight duration play a vital role. Most of vegetable require 6 hours direct sunlight in a day. Although, Leafy vegetables require 4-6 hours of sunlight, while fruiting vegetables like tomato and peppers requires 6-8 hours or even more.

Pest management: Use natural repellents like neem oil, garlic spray, and companion planting to manage pests.

Vegetables and fruits their varieties for kitchen gardening

Name	Recommended variety	Suitable location
Amaranthus	Pusa Lal Chulai	Garden beds, pots
Radish	Pusa Mridula	Beds, containers
Carrot	Royal Chantenay	Raised beds, deep pots

Pea	Alderman	Trellis in garden or pots
Tomato	Angoorlata	Pots, grow bags,
Chekkurmanish	-	garden beds
Papaya	Backyard fruit (Pusa Nanha)	Backyard, open sunny spaces
Mango	Amrapali, Sadabahar	Backyard, large containers
Pineapple	Kew	Backyard, large pots

Strawberry	–	Rooftop, hanging pots/boxes
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Conclusion

Kitchen gardening is a simple, healthful, and environmentally friendly way to cultivate fresh fruits, vegetables, and herbs at home. It not only provides chemical-free nutritious food for the family, but it also encourages self-sufficiency and lowers daily costs. Anyone may establish a kitchen garden in a tiny space, such as a balcony or terrace, with simple tools and organic practices. Aside from enhancing food security and health, it also promotes mental calm and a stronger connection to nature. In today's fast-paced world, kitchen gardening is an important step toward better living and environmental responsibility.

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The Biochemical and Nutritional Benefits of Oats in Human Health

www.agrirootsmagazine.in

ISSN: 2583-9071

ARTICLE ID: 0237

Sheetanu Singh¹, Priya Pandey¹, Garima Dixit³

¹Department of Biochemistry, Acharya Narendra Deva University of Agriculture and Technology

²Department of Food and Nutrition, Acharya Narendra Deva University of Agriculture and Technology

Oats (*Avena sativa* L.) are among the most nutritionally dense cereal grains, offering a range of macro- and micronutrients along with several bioactive compounds that contribute significantly to human health. Traditionally consumed as a breakfast cereal, oats have gained widespread attention in nutritional science due to their potential role in preventing chronic diseases such as cardiovascular disorders, diabetes, and obesity. This article reviews the biochemical and nutritional properties of oats and their associated health benefits, supported by current research.

Nutritional Composition of Oats

Oats are a rich source of carbohydrates, protein, dietary fiber, lipids, vitamins, and minerals. They provide balanced nutrition with low glycemic impact and are considered a functional food due to their health-promoting components.

1. Carbohydrates and Dietary Fiber

Oats contain about 60–70% carbohydrates, primarily in the form of starch (Călinoiu & Vodnar, 2018). However, their high content of soluble dietary fiber, especially β -glucan, distinguishes them from other cereals. β -glucan is a non-starch polysaccharide consisting of mixed-linkage (1 $\rightarrow$ 3, 1 $\rightarrow$ 4)- β -D-glucans, which have been shown to reduce serum cholesterol and postprandial blood glucose levels (Whitehead et al., 2014).

2. Protein Content

Oats contain 12–20% protein, a higher amount than most other grains (Rasane et al., 2015). The protein fraction primarily includes globulins and avenins. Unlike wheat proteins, oat proteins contain relatively low amounts of prolamins, making oats suitable for people with gluten sensitivity when processed correctly. Oat protein is also rich in lysine, an essential amino acid often limited in other cereals.



3. Lipids and Fatty Acids

Oats contain about 5–9% fat, mostly unsaturated fatty acids, including oleic, linoleic, and α -linolenic acids (Zhou et al., 2019). These lipids contribute to cardiovascular health and aid in the absorption of fat-soluble vitamins. Oat oil also contains tocopherols and tocotrienols, which possess antioxidant properties.

4. Vitamins and Minerals

Oats are a good source of several essential vitamins and minerals, such as vitamin E, B-complex vitamins (thiamin, riboflavin, niacin, folate), iron, magnesium, phosphorus, manganese, selenium, and zinc (Peterson, 2001). These micronutrients support metabolic processes, immune function, and oxidative balance.

Bioactive Compounds in Oats

Beyond macronutrients and micronutrients, oats contain several bioactive phytochemicals that exhibit antioxidant, anti-inflammatory, and anti-cancer properties.

1. β -Glucan

The most extensively studied component of oats, β -glucan contributes to several physiological effects, including reduced cholesterol levels, improved glycemic control, and enhanced immune response (Wood, 2007). It increases the viscosity of intestinal contents, delaying gastric emptying and nutrient absorption, thus reducing blood glucose spikes.

2. Avenanthramides

Avenanthramides are a unique group of phenolic alkaloids found almost exclusively in oats. They exhibit strong antioxidant, anti-inflammatory, and anti-atherogenic activities (Emmons & Peterson, 2001). Avenanthramides have been shown to inhibit LDL

oxidation and reduce endothelial adhesion molecule expression, which are crucial factors in atherosclerosis development (Guo et al., 2008).

3. Phenolic Acids and Flavonoids

Oats are rich in phenolic acids such as ferulic, caffeic, and p-coumaric acid, and flavonoids like apigenin, tricetin, and kaempferol (Sadiq Butt et al., 2008). These compounds contribute to the antioxidant potential of oats and may provide protective effects against chronic diseases, including cancer and neurodegenerative disorders.

Health Benefits of Oats

1. Cardiovascular Health

Numerous studies have confirmed that oat β -glucan lowers total and LDL cholesterol levels, reducing the risk of coronary heart disease (CHD). A meta-analysis by Whitehead et al. (2014) demonstrated that a daily intake of 3 grams of β -glucan reduces LDL cholesterol by approximately 5–10%. Avenanthramides further contribute by preventing oxidative damage to LDL and improving vascular function.

2. Glycemic Control and Diabetes Management

Oats have a low to moderate glycemic index, and their β -glucan content slows the absorption of glucose, leading to improved glycemic control. Clinical trials have shown that oats reduce postprandial blood glucose and insulin responses in both healthy individuals and patients with type 2 diabetes (Tappy et al., 1996).

3. Digestive Health

Oats improve bowel regularity and promote gut health due to their high fiber content. The fermentation of β -glucan by gut microbiota leads to the production of

short-chain fatty acids (SCFAs), which have anti-inflammatory effects and support colon health (Călinoiu & Vodnar, 2018).

4. Weight Management

Oats enhance satiety due to their high fiber and protein content. Studies suggest that consuming oats may reduce appetite and total energy intake throughout the day, aiding in weight control (Rebello et al., 2016).

5. Skin Health

Oats have been used in dermatological products for treating conditions such as atopic dermatitis and eczema. Colloidal oatmeal is approved by the FDA as a skin protectant, and avenanthramides play a key role in reducing itching and inflammation (Sur et al., 2008).

6. Cancer Prevention

The antioxidant activity of oat polyphenols may reduce DNA damage and modulate pathways involved in cancer progression. Though more human studies are

needed, in vitro studies have shown potential anticancer effects of avenanthramides and oat extracts (Chen et al., 2004).

Conclusion

Oats are a nutritionally rich cereal grain with a wide array of health benefits attributed to their unique biochemical composition. The presence of β -glucan, avenanthramides, and various polyphenols makes oats an excellent dietary choice for promoting cardiovascular health, improving glycemic control, supporting digestive health, aiding weight management, and protecting the skin. As a functional food, oats offer a cost-effective, natural strategy for the prevention and management of chronic lifestyle diseases. Incorporating oats into daily dietary habits could significantly contribute to long-term health and well-being.

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The Influence of Temperature on Cereal Crop Pests

www.agrirootsmagazine.in

ISSN: 2583-9071

ARTICLE ID: 0238

Dr. Pramod S. Kamble¹, Lokesh Baghele²

¹Assistant Professor, Department of Agricultural Meteorology, Shri Vaishnav Institute of Agriculture, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore (Madhya Pradesh)

²Department of Soil Science and Agricultural Chemistry, Shri Vaishnav Institute of Agriculture, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore (Madhya Pradesh)

Temperature is a pivotal environmental factor governing the development, activity, and population dynamics of insect pests in agricultural ecosystems. Cereal crops, including sorghum, pearl millet, maize, and rice, are staple foods for a significant portion of the global population, but their yields are consistently threatened by a diverse array of insect pests. This review synthesizes existing knowledge on the optimal

Cereal crops form the backbone of global food security, providing essential carbohydrates and nutrients. However, their productivity is continually challenged by insect pests that cause significant yield

losses. Among the various environmental factors, temperature stands out as a critical determinant of insect life processes. As poikilothermic (cold-blooded) organisms, insects' metabolic rates,



temperature ranges for key pests affecting these major cereal crops, highlighting how temperature variations influence their life cycles, reproduction, and overall impact on crop production. Understanding these thermal requirements is crucial for developing effective and sustainable Integrated Pest Management (IPM) strategies in the face of changing climatic conditions.

development, reproduction, and survival are directly influenced by ambient temperatures. Variations in temperature, both within a season and across years, can significantly impact pest pressure, leading to outbreaks or suppressed populations. This review aims to compile and present the temperature ranges that are optimal for the development and activity of common pests of sorghum, pearl millet, maize, and rice, thereby

offering insights for improved pest management. Temperature is a critical abiotic factor that profoundly influences the biology and ecology of cereal crop pests, affecting their development, reproduction, survival, distribution, and the severity of their impact on crops. With ongoing climate change and rising global temperatures, these influences are becoming increasingly significant for food security.

1. Accelerated Development and Increased Generations

As insects are ectothermic (cold-blooded), their metabolic rates and developmental speeds are highly dependent on ambient temperature. Within their optimal temperature range, higher temperatures lead to faster development from egg to adult.

More Generations per Year: This accelerated development means that many pest species can complete more generations within a single growing season. More generations directly translate to higher pest populations and, consequently, more extensive crop damage. For example, a 2°C temperature increase could lead to one to five additional life cycles per season for some insects.

Earlier Emergence: Warmer spring temperatures can trigger earlier emergence of overwintering pests, potentially leading to a desynchronization with their natural enemies or a prolonged period of activity during the crop's vulnerable stages.

2. Geographical Range Expansion

Pole Ward and Altitudinal Shifts: Many insect species' geographic ranges are limited by temperature, particularly by minimum temperatures that affect overwintering survival. As global temperatures rise,

these species can expand their ranges towards higher latitudes (pole ward) and higher altitudes, colonizing areas previously too cold for them. This means that regions currently unaffected by certain pests may become vulnerable.

Introduction of Invasive Species: Warmer conditions can facilitate the establishment of invasive pest species that previously couldn't survive in a given climate. Increased global trade, coupled with rising temperatures, further exacerbates this risk.

3. Population Dynamics and Survival

Increased Overwintering Survival: Warmer winters reduce winterkill, leading to higher initial pest populations in the subsequent growing season.

Changes in Reproduction: Temperature directly impacts pest reproduction rates. While generally higher temperatures within an optimal range increase reproduction, excessively high temperatures can have detrimental effects, reducing longevity and reproduction. **Altered Feeding and Growth:** Increased temperatures can raise the metabolic rate of some insects, leading to higher food consumption and more intensive feeding on crops.

4. Impact on Host Plants and Plant-Pest Interactions

Plant Stress: High temperatures can stress cereal crops, weakening their natural defense systems and making them more susceptible to pest attacks.

Changes in Plant Physiology: Climate change can alter plant growth patterns, including the timing of leaf, stem, flower, or fruit formation. This can impact the insect's life cycle, potentially causing them to stay

longer on the host or produce more generations if conditions remain favorable.

Indirect Effects of Elevated CO₂: While temperature has direct effects, elevated CO₂ concentrations (another aspect of climate change) can indirectly influence pests by altering plant chemistry, physiology, and nutritional content.

5. Disruption of Natural Enemy-Pest Interactions:

Asynchrony: The development rates of pests and their natural enemies (predators and parasitoids) may respond differently to temperature changes. This can lead to a desynchronization, where the natural enemies are not present in sufficient numbers at the critical time to control the pest population effectively.

Differential Responses: Generalist and specialist natural enemies may respond differently to changing climatic conditions, potentially altering the balance of pest control.

Temperature Thresholds

Insects, like plants, have cardinal temperatures:

Lower Developmental Threshold (T_{base})

The minimum temperature below which an insect cannot complete development. This helps predict when pests become active after overwintering. Optimal Temperature (Topt): The temperature range at which an insect develops most rapidly and thrives. Upper Developmental Threshold (Tupper) or Lethal Maximum Temperature (Tlmax): The highest temperature at which an insect can develop. Beyond

this point, high temperatures can slow growth, reduce numbers, and even lead to mortality. These thresholds are crucial for developing predictive models (e.g., using Growing Degree Days - GDD) to forecast pest emergence and population build-up, aiding in timely pest management strategies.

Major Cereal Crop Pests Affected by Temperature

Many common cereal crop pests are significantly influenced by temperature. Examples include: Aphids (e.g., Wheat Aphid): Their populations can increase rapidly with favorable temperatures, leading to significant sap-sucking damage. Stem Borers (e.g., Pink Stem Borer, European Corn Borer): Warmer conditions can lead to more generations and prolonged periods of boring activity within cereal stems. Leaf Folders (e.g., Rice Leaf Folder): Their developmental periods are reduced with increasing temperatures within their optimal range. Armyworms: Their development and outbreaks are often linked to specific temperature and moisture conditions.

Locusts: Warming trends can lead to range expansion and an increase in locust populations, potentially resulting in devastating plagues.

2. Temperature Requirements of Sorghum Crop Pests

Sorghum (*Sorghum bicolor* (L.) Moench) is a crucial cereal crop, particularly in arid and semi-arid regions. Its pests generally thrive in warm to hot climates, typically between 25°C and 35°C (77°F to 95°F).

Pest	Optimal Temperature Range	Notes
Sorghum Shoot Fly (<i>Atherigona soccata</i>)	25°C – 30°C	Eggs and larvae develop faster in this range; high humidity also favors population buildup.

Sorghum Midge (<i>Stenodiplosis sorghicola</i>)	27°C – 32°C	Activity peaks during warm, humid conditions during flowering.
Stem Borers (<i>Chilo partellus</i> , <i>Busseola fusca</i>)	25°C – 33°C	Larval development and adult activity increase with temperature.
Aphids (<i>Melanaphis sacchari</i>)	20°C – 30°C	Rapid population growth in warm, moderately humid conditions.
Shoot Bug (<i>Peregrinus maidis</i>)	28°C – 35°C	Favors dry and hot conditions; thrives in post-monsoon or dry spells.
Cutworms (<i>Agrotis spp.</i>)	15°C – 28°C	Prefer cooler temperatures; more active at night.
White Grubs	25°C – 30°C	Soil temperature plays a significant role in larval development.

General Guidelines for Sorghum Pests

- **Below 20°C:** Most pests show reduced activity and reproduction.
- **25°C – 35°C:** Ideal for most pest development, especially in tropical and subtropical climates.
- **Above 38°C:** Can suppress pest development or increase mortality in some species.

3. Temperature Requirements of Pearl Millet Crop Pests

Pearl millet (*Pennisetum glaucum*) is well-adapted to arid and semi-arid regions, and its associated pests are similarly adapted to warm to hot conditions, primarily within the 25°C to 35°C (77°F to 95°F) range.

Pest	Optimal Temperature Range	Notes
Shoot Fly (<i>Atherigona approximata</i>)	25°C – 30°C	More active during warm and humid conditions, especially at seedling stage.
Stem Borer (<i>Coniesta ignefusalis</i>)	25°C – 32°C	High temperatures speed up larval development.
Aphids (<i>Rhopalosiphum maidis</i>)	20°C – 30°C	Rapid multiplication in moderate warmth and moderate humidity.
White Grubs (<i>Holotrichia spp.</i>)	25°C – 30°C	Thrive in warm soils with moderate moisture.
Grasshoppers (<i>Hieroglyphus spp.</i>)	30°C – 38°C	Prefer hot, dry environments typical of millet-growing regions.
Earhead Worms (<i>Helicoverpa armigera</i>)	25°C – 33°C	Egg-laying and larval activity peak in this range.

General Temperature Impacts on Pearl Millet Pest Activity

- **<20°C:** Slowed pest metabolism and reproduction.

- **25–35°C:** Ideal for pest development; most pearl millet pests are highly active in this range.

- **>38°C:** Can reduce survival or egg viability for some pests, though others (e.g., grasshoppers) may still thrive.

4. Temperature Requirements of Maize Crop Pests

Maize (*Zea mays*) is a globally significant cereal, and its pests exhibit varying temperature preferences, generally favoring warm conditions for optimal development.

Pest	Optimal Temperature Range	Notes
Fall Armyworm (<i>Spodoptera frugiperda</i>)	28°C – 30°C	High temperatures accelerate development; thrives in warm climates.
Stem Borer (<i>Chilo partellus</i> , <i>Busseola fusca</i>)	25°C – 33°C	Warmer temperatures favor multiple generations per season.
Corn Earworm (<i>Helicoverpa armigera</i>)	27°C – 32°C	Prefers warm, dry conditions; attacks ears and kernels.
Maize Aphid (<i>Rhopalosiphum maidis</i>)	20°C – 30°C	Rapid population increase in moderate warmth and humidity.
Rootworm (<i>Diabrotica</i> spp.)	25°C – 30°C	Soil temperature affects larval emergence and development.
Cutworms (<i>Agrotis</i> spp.)	15°C – 28°C	Prefer cooler nights and moist soil; early-season pest.
White Grubs (<i>Holotrichia</i> spp.)	25°C – 30°C	Soil temperature and moisture influence larval growth.
Stalk Borer (<i>Papaipema nebris</i>)	22°C – 28°C	Moderate temperature and humidity favor larval development.

Temperature Impact Summary for Maize Pests

- **<20°C:** Most pests develop slowly; some may become inactive.
- **25°C – 35°C:** Ideal range for most maize pests; favors high reproductive and feeding rates.
- **>35°C:** Can be stressful to certain pests but may benefit heat-tolerant ones like *Spodoptera frugiperda*.

5. Temperature Requirements of Rice Crop Pests

Rice (*Oryza sativa*) is a staple crop for a large part of the world, particularly in Asian countries. Rice pests are largely adapted to warm, humid, and often tropical or subtropical climates.

Pest	Optimal Temperature Range	Notes
Brown Plant hopper (<i>Nilaparvata lugens</i>)	27°C – 30°C	High humidity and warm temperatures promote rapid reproduction.
White-Backed Planthopper (<i>Sogatella furcifera</i>)	25°C – 30°C	Similar to brown planthopper; prefers moist, warm climates.
Rice Stem Borer (<i>Scirpophaga incertulas</i> , etc.)	25°C – 33°C	Larval development and pupation accelerate in warm temperatures.

Rice Leaf Folder (<i>Cnaphalocrocis medinalis</i>)	27°C – 32°C	Most damaging during high humidity and moderate to high temperatures.
Gall Midge (<i>Orseolia oryzae</i>)	25°C – 30°C	Outbreaks common during high humidity and cloudy weather.
Rice Hispa (<i>Dicladispa armigera</i>)	28°C – 35°C	Population builds up in warm, dry conditions.
Rice Water Weevil (<i>Lissorhoptrus oryzophilus</i>)	20°C – 30°C	Prefers slightly cooler temperatures, but can adapt to warmer ones.
Armyworms (<i>Mythimna separata</i>)	24°C – 30°C	Thrive in warm, moist climates; major outbreaks after rains.

Temperature Impacts on Rice Pests

- **Below 20°C:** Slows down pest development significantly; some may enter dormancy or die.
- **25°C – 35°C:** Ideal for the growth, reproduction, and spread of most rice pests.
- **Above 35°C:** Can reduce survival or fertility of some pests, but others like Rice Hispa may still thrive.

6. Conclusion and Future Implications

The information presented highlights the strong dependency of cereal crop pests on specific temperature ranges for their optimal development and activity. While most cereal pests generally thrive in warm to hot conditions (25°C to 35°C), there are species-specific variations and tolerances to temperature extremes. Understanding these thermal thresholds is fundamental for predicting pest

outbreaks, assessing the risk of new invasive species under changing climates, and developing climate-resilient pest management strategies.

As global temperatures continue to rise, it is anticipated that pest geographic ranges may expand, overwintering survival may increase, and the number of generations per season could intensify. This necessitates ongoing research into the precise thermal biology of cereal pests, including their physiological responses to fluctuating temperatures, heat stress, and the interaction of temperature with other environmental factors like humidity and rainfall. Integrating this knowledge into predictive models and early warning systems can significantly enhance the effectiveness of IPM programs, contributing to food security in a changing world.

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