Open Access Multidisciplinary Online Magazine

Agri-India TODAY

Monthly Magazine-cum-eNewsletter
ISSN : 2583-0910
Volume 05 | Issue 06 | June 2025

www.agriindiatoday.in

Editorial Board

INDEX

Article No	Title	Page No.
05/VI/01/0525	**CITRUS DECLINE: BIOTIC THREATS AND INTEGRATED SOLUTIONS** Samiksha Chettri	1-4
05/VI/02/0525	**MAGNETIC AND IRRADIATION SEED TREATMENT TECHNIQUES IN PULSES** Sindhu Lakshmi R and Gomathi S	5-7
05/VI/03/0525	**AN OVERVIEW OF GREEN WEAPONS TO MITIGATE NOISE POLLUTION- A BENEVOLENT CONTRIBUTION TO HUMANKIND** Krishna Biswas and Divya Kumari	8-13
05/VI/04/0525	**SUSTAINABLE ALTERNATIVES TO FISH MEAL AND FISH OIL IN AQUACULTURE** Sarvendra Kumar, Showkat Ahmad Dar, Susmita Rani, Md Aman Hassan and Aman Divakar	14-17
05/VI/05/0525	**REVIVING PULSES: A STRATEGIC PATHWAY TO SUSTAINABLE AGRICULTURE AND NUTRITIONAL RESILIENCE IN INDIA** Pratibha Sharma and Jeenia Thalyari	18-20
05/VI/06/0525	**BIOFORTIFICATION: AN ECOLOGICAL APPROACH TO ADDRESSING HIDDEN HUNGER** Soumen Mandal and Ankan Ghosh	21-22
05/VI/07/0525	**BIOFORTIFICATION IN AGRICULTURAL CROPS – A WAY TO FIGHT MALNUTRITION** Priyanka Chand and D.V Singh	23-25
05/VI/08/0525	**SAFEGUARDING SHRIMP FARMS: A COMPREHENSIVE GUIDE TO BIOSECURITY** Prasanna Laxmi U, Sirisha H., Kranthi Kumar D, Aitwar Vaijnath S, Usha A, Chamundeshwari B, Nikhil K, Neha P and Kishore Kumar M	26-28
05/VI/09/0525	**MOLYBDENUM DEFICIENCY AND CORRECTIVE MEASURES** K. N. Tiwari	29-38
05/VI/10/0525	**CAPTIVE BREEDING OF STRIPED CATFISH (*Pangasianodon hypophthalmus*) USING DIFFERENT INDUCING AGENTS** S. Selvaraj, T.L.S. Samuel Moses, P. Ruby, V. Ezhilarasi, A. Jackqulin Wino and R. Jeya Shakila	39-44
05/VI/11/0525	**AI AND MACHINE LEARNING APPLICATIONS IN PEST FORECASTING: AN INDIAN PERSPECTIVE** Shanmugapriya V and S. Karthikeyan	45-47
05/VI/12/0525	**CHAMOMILE: A STAR OF MEDICINAL PLANTS** Anamika Sajwan, Harshita Bora, Mukesh Kumar and V K Rao	48-50
05/VI/13/0525	**MANAGEMENT OF SOIL COMPACTION IN AGRICULTURAL FIELDS** Abishek, Sunil Shirwal, Maheshwari and Satish	51-51
05/VI/14/0525	**CONSERVATION AGRICULTURE: A SUSTAINABLE PARADIGM FOR SOIL HEALTH, CLIMATE RESILIENCE, AND GLOBAL FOOD SECURITY** Mohd Anas, Asheesh Kumar, Sumaiya, G.K. Mahapatro and C.M. Parihar	55-58
05/VI/15/0525	**DELAY IN RIPENING OF FRUIT CROPS** Shaipharson Syngkon	59-61
05/VI/16/0525	**VARIOUS EDIBLE FLOWERS AND THEIR IMPORTANCE** Nalanda Acharya	62-64
05/VI/17/0525	**EFFECT OF BIO STIMULANT IN HORTICULTURAL SEEDS** S. Gomathi and R. Sindhu Lakshmi	65-68

INDEX

Article No	Title	Page No.
05/VI/18/0525	**EMERGING PEST CHALLENGES: CLIMATE-SMART STRATEGIES FOR RESILIENT AGRICULTURE** Sake Manideep, Neha Singh, Amalendu Ghosh and Amrita Das	69-72
05/VI/19/0525	**AGRIVOLTAICS AND AGRICULTURAL ELECTRIC VEHICLES TOWARDS SELF SUSTAINABLE AGRICULTURAL OPERATIONS** Jyotirmay Mahapatra, Vikas Pagare and Abhishek Patel	73-77
05/VI/20/0525	**ENTOMOPATHOGENIC NEMATODE (EPN) FOR THE MANAGEMENT OF ROOT GRUB (*Basilepta fulvicorne*) IN CARDAMOM (*Elettaria cardamomum*)** Seema Yadav, B. L. Baheti, Dinesh Kumar Yadav and Rajendra Yadav	78-80
05/VI/21/0525	**CONSERVATION AGRICULTURE AND SUSTAINABLE DEVELOPMENT GOALS** Abhishek Meena, Shruti Setia and Shreyas Bagrecha	81-85
05/VI/22/0525	**READY TO EAT- FOXTAIL MILLET** N. Gobikashri, S. Punithkumar and C. Nivetha	86-90
05/VI/23/0525	**GMOS VS GENE EDITING: A CLEAR DIVIDE IN MODERN CROP BIOTECHNOLOGY** Purva Khandelwal	91-95
05/VI/24/0525	**MAJOR SOURCES OF HEAVY METAL CONTAMINATION** Jitesh Singh, Seerat Thind, Amrit Sadhana and Md Mera	96-100
05/VI/25/0525	**THE BEE WHISPERER: A CENTURY DEVOTED TO SWEETNESS** Rakesh Yonzone and Maimom Soniya Devi	101-104
05/VI/26/0525	**HOW SOIL CHEMISTRY INFLUENCES PLANT NUTRITION** R. Rebecca, S.U. Vikraman and K. Suriya	105-108
05/VI/27/0525	**FROM WASTE TO WEALTH: HOW INSECT FRASS BOOSTS SOIL WITHOUT SYNTHETICS** Pungavi Ramakrishnan, Bala Murgan S and Priyadharshini Velayutham	109-111
05/VI/28/0525	**LIVESTOCK SECTOR: A BOON OR BANE TO THE INDIAN FARMERS AND ECONOMY** Neetu Nehra, Sarthak and Pulkit Chugh	112-116
05/VI/29/0525	**FROM WILD GRASS TO LIFELINE: THE JOURNEY OF RICE THROUGH HISTORY AND BEYOND** Debobrata Dey, Snehasree Samanta and Arnab Mandal	117-120
05/VI/30/0525	**MECHANISM AND EXAMPLES OF SEX LINKED; SEX LIMITED; SEX INFLUENCE INHERITANCE** P. Lasya Prasuna, D. Mamatha, P. Anand Prasad, M. Joshna, Salkapuram Sandeep Kumar, SK. Sameera, M. Shiny Rachel and N. Arun Kumar	121-125
05/VI/31/0525	**MICROPLASTIC TOXICITY IN AQUAFEEDS AND WATER BODIES** Jitesh Singh, Seerat Thind, Upjeet Kour Tulla and Prachee Keshavrao Kumbhare	126-131
05/VI/32/0525	**NANO UREA: INNOVATION OR HYPE?** Garvita Jaiswal, Simran Vats, Aditya Kumar Giri and Ankit Singh Bhadauria	132-135
05/VI/33/0525	**THE ONE HEALTH APPROACH TO FISH, HUMAN AND ENVIRONMENTAL WELL-BEING** Santhiya. V, Kaviarasu. D, Saravanan. S and Porselvan. S	136-139
05/VI/34/0525	**SAVING EVERY DROP: INNOVATIVE WAYS TO CONSERVE WATER ON FARMS** Arup Mondal and Sourakanti Sarkar	140-144
05/VI/35/0525	**POSTHARVEST PHYSIOLOGY OF CUT FLOWERS** Nalanda Acharya	145-147

INDEX

Article No	Title	Page No.
05/VI/36/0525	**PROCESSED FOOD PRODUCTS: BUSTING THE MYTHS WITH FACT** Anshu Sharma	148-150
05/VI/37/0525	**SEEDS OF HOPE: A NEW ERA OF CLIMATE-READY AGRICULTURE IN INDIA** Adrita Dam and Partha Mondal	151-154
05/VI/38/0525	**SMART AQUAPONICS: INTEGRATING AI AND IOT FOR SMART FARMING IN INDIA** Bharath G and Murtaza Hasan	155-158
05/VI/39/0525	**A SUCCESS STORY OF AN ORGANIC FARMER OF BAREILLY DISTRICT OF UTTAR PRADESH** Monika Jha, Snehasish Routray, Kailashpati Tripathi, Ashutosh Fular, Mranalini Prerna, Anjali, K.A. Saravanan, Jagdish Goyanka, Anuj Chauhan, Brijesh Kumar, Rupasi Tiwari and S. K. Soam1	159-164
05/VI/40/0525	**MORPHOTYPES OF SWEET ORANGE FOUND IN MANIPUR, NE INDIA** S. Romen Singh and Rahul Senjam	165-167
05/VI/41/0525	**UNRAVELING FASHION'S CARBON FOOTPRINT: STEPS TOWARD A GREENER FUTURE** Minakshi Sharma and Parul Gill	168-172
05/VI/42/0525	**VERTICAL FARMING: INDOOR FARMING USING HYDROPONICS, AEROPONICS, AND LED LIGHTING TO GROW FOOD IN URBAN AREAS WITH MINIMAL RESOURCES** Kishor K. Anerao, Monali M. Joshi, Sachin A. Giri, Prasad S. Gangakhedkar, Radha M. Lolge and Shaikh Ajaj	173-177
05/VI/43/0525	**CONCEPT OF CONTROLLED TRAFFICKING FARMING SYSTEMS IN INDIA** Maheshwari, Sunil Shirwal, Abhishek and Satish	178-181

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/01/0625

CITRUS DECLINE : BIOTIC THREATS AND INTEGRATED SOLUTIONS

Samiksha Chettri

Research Scholar, Department of Horticulture,
Sikkim University, Gangtok, Sikkim-737102
Corresponding Email: sam99chettri@gmail.com

Abstract

Citrus decline, a multifaceted syndrome threatening global citriculture, arises from complex interactions among pathogens, environmental stressors, and suboptimal agricultural practices. *Candidatus* Liberibacter asiaticus-induced Huanglongbing (HLB) and *Phytophthora* spp.-mediated root rot synergistically compromise tree health, reducing yields by 30–75% in major citrus regions (Bové, 2006; Graham *et al*., 2013). Economic losses exceed $39 million annually in high-incidence areas, exacerbated by climate-driven pest proliferation and inadequate access to disease-free planting material (Timsina *et al*., 2025). Integrated strategies combining CRISPR-edited rootstocks, precision agriculture, and soil microbiome enhancements show promise in restoring orchard productivity, though socioeconomic barriers hinder widespread adoption (Dutt *et al*., 2021;). Prioritizing climate-resilient cultivars and farmer education remains critical for sustainable mitigation.

Keywords: Citrus decline, Huanglongbing, *Phytophthora*, Integrated management, Climate resilience

Introduction

Citrus decline, a syndrome characterized by the gradual deterioration of citrus orchards, has emerged as a critical challenge for growers worldwide. This phenomenon, marked by reduced yields, poor fruit quality, and eventual tree death, stems from a synergistic interplay of biotic, abiotic, and anthropogenic factors. It is a multifaceted crisis, which threatens the livelihoods of millions of farmers and the stability of a $10 billion global industry (Poudel *et al*., 2022; Bassanezi *et al*., 2009).

The Pathogen Onslaught: Huanglongbing and Beyond

Huanglongbing (HLB), caused by *Candidatus* Liberibacter asiaticus, remains the most devastating citrus disease. Transmitted by the Asian citrus psyllid (*Diaphorina citri*), HLB disrupts phloem function, leading to asymmetrical fruit development, bitter-tasting juice, and premature fruit drop (Bové, 2006). In Florida, HLB incidence surged from 0.2% to 39% within 10 months in newly infected groves, rendering 70% of orchards unproductive within a decade (Gottwald *et al*., 2007). The disease's rapid spread is facilitated by the psyllid's ability to transmit pathogens during brief feeding periods, with secondary spread occurring through infected nursery stock.

The Human Factor: Management Missteps and Climate Pressures

Citrus decline is inextricably linked to suboptimal orchard practices. A study in Nepal revealed that 72% of orchards exhibited decline symptoms due to inadequate spacing, excessive intercropping, and poor irrigation management (Poudel *et al*., 2022). The reliance on uncertified planting material further perpetuates disease transmission—a problem magnified in smallholder systems where 60%

of growers lack access to pathogen-free saplings (FAO, 2011). Conversely, erratic rainfall in Florida promotes *Phytophthora* zoospore dispersal, creating a vicious cycle of root damage and nutrient deficiency (Graham *et al.*, 2013).

Figure a: Affected trees

Economic Fallout: From Orchard to Market

The economic repercussions are staggering. Brazil's Paranavaí region lost $39.2 million annually due to HLB-induced production declines, while Florida's citrus output plummeted by 75% between 2005–2015 (Telles et al., 2018). Smallholders bear the brunt—in Nepal, 35% of farmers abandoned citrus cultivation entirely after 5 years of decline (Timsina *et al*., 2025). Market dynamics compound these losses. HLB-affected oranges exhibit 40% lower soluble solids, rendering them unsuitable for premium juice markets (Baldwin *et al*., 2010).

Integrated Solutions:

Effective management requires the following approaches:

- **Vector Control**: IPM strategies combining kaolin clay sprays, guava intercropping, and targeted insecticides reduce psyllid populations by 80% (Qureshi *et al*., 2014).
- **Pathogen Suppression**: Trunk-injected oxytetracycline and phosphite fungicides improve tree health but require precise dosage to avoid resistance (Bové2, 006).
- **Cultural Practices**: Subsurface drainage systems, timely rejuvenation of orchards and resistant rootstocks like *Citrus macrophylla* mitigate *Phytophthora* damage (Graham *et al*., 2013).
- **Genetic frontiers**: CRISPR-edited citrus lines with enhanced HLB tolerance are undergoing field trials, while spectral imaging enables early disease detection (Dutt *et al*., 2021).

Figure b: Farmer selling their produce

Toward Sustainable Citriculture

Addressing citrus decline demands global collaboration. Equally critical is addressing socioeconomic barriers—subsidizing certified saplings in India increased adoption rates from 12% to 58% within 3 years (Telles *et al*., 2018).

Conclusion

Integrated Pest Management (IPM) strategies—combining biological controls (e.g., natural predators), cultural practices (e.g., orchard sanitation to remove 75% of pests), and selective chemical use offer promise in mitigating losses (Qureshi e*t al*., 2014). Additionally, adopting disease-resistant rootstocks, improving soil health through organic amendments, and fostering community-led initiatives (e.g., farmer cooperatives for knowledge-sharing) are critical for long-term resilience (Dutt e*t al.*, 2021). Addressing citrus decline thus demands holistic approaches that bridge scientific innovation with on-ground agricultural stewardship.

References

Baldwin, E. A., Plotto, A., & Goodner, K. (2010). Shelf-life versus flavour-life for fruits and vegetables: How to evaluate this complex trait. Postharvest Biology and Technology, 57(1), 129–135.

Bassanezi, R. B., Montesino, L. H., & Stuchi, E. S. (2009). Effects of huanglongbing on fruit quality of sweet orange cultivars in Brazil. Plant Disease, 93(4), 317–323.

Bové, J. M. (2006). Huanglongbing: A destructive, newly-emerging, century-old disease of citrus. Journal of Plant Pathology, 88(1), 7–37.

Dutt, M., Barthe, G., Irey, M., & Grosser, J. (2021). CRISPR-mediated editing of CsLOB1 confers resistance to citrus canker. Plant Biotechnology Journal, 19(5), 868–88.

Food and Agriculture Organization [FAO]. (2011). *Citrus decline in Asia and the Pacific*. FAO Regional Office.

Gottwald, T. R., da Graça, J. V., & Bassanezi, R. B. (2007). Citrus huanglongbing: The pathogen and its impact. Plant Disease, 91(5), 629–636.

Graham, J. H., Johnson, E. G., Gottwald, T. R., & Irey, M. S. (2013). Phytophthora-Diaprepes complex: A major constraint to citrus production in Florida. Phytopathology, 103(6), 501–511.

Poudel, Anit & Sapkota, Sabina & Pandey, Nabin & Oli, Dipesh & Regmi, Rajiv. (2022). Causes of Citrus Decline and its Management Practices Adopted in Myagdi District, Nepal. Heliyon. 8. e09906.

Qureshi, J. A., Rogers, M. E., Hall, D. G., & Stansly, P. A. (2014). Insecticidal suppression of Asian citrus psyllid in Florida groves. Pest Management Science, 70(7), 1098–1106.

Timsina, A., Paudel, S., & Dhakal, S. C. (2025). Socio-economic factors affecting the adoption of improved orchard management practices of mandarin in Sankhuwasabha, Nepal. Cogent Food & Agriculture, 11(1).

Telles, T. S., de Souza, R. G., Machado, J. G., & Mello, L. M. R. (2018). Economic impact of huanglongbing on Paranavaí citrus belt, Brazil. Ciência Rural, 48(6), e20170698.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/02/0625

MAGNETIC AND IRRADIATION SEED TREATMENT TECHNIQUES IN PULSES

Sindhu Lakshmi R[1*] and Gomathi S[2]

[1]M.Sc. Scholar, Department of Seed Science and Technology,
Agricultural College and Research Institute, Madurai-625104, Tamil Nadu, India
[2] Research Scholar, Department of Seed Science and Technology,
Agricultural College and Research Institute, Madurai-625104, Tamil Nadu, India
*Corresponding Email: sindhulakshmi1910@gmail.com

Abstract

Pulses is the common term that refers to the edible seeds of the legume plant. Pulses belongs to the family Fabaceae and includes crops like black gram, green gram, peas, beans and lentils etc. Pulses are used for many purposes like human consumption, silage and forage. Pulses are an important source of plant-based protein. Major disadvantage of pulse crops are their decreased productivity due to their hard seed coat, in-order to overcome this problem pulse seeds are subjected to various seed treatments, amongst them physical seed treatment are considered to be more advantageous because they are environment friendly and does not cause any pollution. Magnetic and irradiation treatment are more effective forms of physical seed treatment.

Keywords: germination, irradiation, pulses.

Introduction

Pulses belong to the family Fabaceaeand they are vital to the average person's diet as they are a good source of plant protein. Pulses are known as "poor man's meat," as it contains 20% to 30% protein. India leads the world in both acreage and production (31% and 28%, respectively), with more than 28 million hectares under cultivation. The major drawback in pulses is low productivity. This is because of the lack of adoption of improved varieties, non-adoption of appropriate seed management practices, non-availability of quality seeds, hard seeds and poor seed storage. Physical seed treatment like magnetic and irradiation treatment exports energy into the targeted cells of seeds and induces seed germination by the activation of enzymes and biochemical processes in cost effective and eco-friendly manner than chemical seed treatment.

Magnetic seed treatment

In recent years, the use of magnetic and electro-magnetic treatments has become more significant among all physical treatments. The germination rate is raised by pre-sowing seed treatment using various methods. Electrical items provide an electromagnetic field, while permanent magnets or PRISMA- magnetic coils create a magnetic field that seeds are exposed to during magnetic treatment (Teixeira *et al.,* 2016). It has been demonstrated that magnetic treatment significantly affects a number of seed properties including germination, the ability of plant tissue to develop, nutrient intake, and chlorophyll synthesis. Magnetic stimulation of seeds had a favourable effect on the emergence and sprouting of pea cultivars. When pulse seeds were exposed to various magnetic fields, all germination variables, including germination percentage and speed of germination, revealed an overall stimulating impact.

Table 1: Effect of magnetic treatment in pulses

S. No	Crop	Treatment	Effect	Reference
1	Chickpea (*Cicer arietinum*)	Chickpea seeds are treated in magnetic field at 0,50,100,150,200,250 mT	Germination percentage was higher for the seeds treated in magnetic field at 100 mT.	(Vashisth *et al.*,2008)
2	Green gram (*Vigna radiata*)	Green gram seeds are exposed to magnetic field at 87-226 mT.	Increasing intensity of magnetic field led to increase in time and mean germination rate.	(Mahajan *et al.*, 2014)
3	Pea (*Pisum sativum*)	Pea seeds are treated in magnetic field for ,10,15 min at 60,120,180 mT respectively.	Shoot length and shoot dry-mass was high when seeds are treated @ 180 mt for 5min.	(Iqbal *et al.*, 2012)

Irradiation treatment

Different types of irradiation treatments are used in agriculture to guarantee higher crop yields and germination rates. While larger radiation doses have negative effects on seed, lower doses improve germination and vigour in a variety of crops.

Three distinct wavelengths of UV light have a beneficial effect on seedling vigour and germination in pulses. During the early phases of germination, the activation of RNA or protein synthesis was encouraged by more powerful radiations that had a significant impact on the outer layer of plant cells. In addition to increasing biochemical substances, such as chlorophyll, gamma irradiation can be employed to improve the germination and seedling parameters (Amir *et al*., 2018). Impact on seed germination depends on the type of seed used, period of exposure and developmental stage of the seed. Ultraviolet irradiation of seeds is an eco-friendly and low-cost approach to "awaken" the seeds from dormancy and increase germination.

Table 2: Effect of Irradiation treatment in pulses

S. No	Crop	Treatment	Effect	Reference
1	Broad bean (*Vigna faba)*	Broad bean seeds were exposed to gamma radiation ofdosage (mGy) control, 16.2,48.5,431 and 1070.	Seeds treated with gamma radiation at 48.5 mGy and at 1070mGy showed highest germination	(Atteh *et al.,*2022)
2	Garden pea (*Pisum sativum)*	Garden pea seeds were exposed to gamma radiation of dosage (mGy) control,16.2, 48.5, 431, 1070.	Seeds treated with gamma radiation @ 16.2 mGy showed higher germinationpercentage.	(Atteh *et al.,*2022)
3	Pea (*Pisum sativum)*	Pea seeds were exposedto gamma radiation of dosage at control,1kR, 5kR, 10kR, 15kR, 20kR, 25kR,30kR, 35kR.	Seeds treated with gamma radiation showed lowest germination percentage compared to control. Lower dose (10kR) the highest plant height was observed which may be due to stimulatory effect of irradiation treatment.	(Verma *et al.*,2017)

Conclusion

Seed invigoration is effective way to boost agricultural output and helps to attain sustainable food security. Irradiation treatments are a rapid, economical, and environmentally friendly way to encourage seed germination. Out of all the physical seed treatments, irradiation and magnetic seed treatment were found to be highly effective and highly recommended. Large-scale production of irradiated seeds is possible with careful planning, including choosing the right irradiation source and dosage, using the right irradiation method, and treating the seeds safely after irradiation. It is anticipated that further investigation and advancement of magnetic and irradiation technologies will be essential in tackling the difficulties of modern agriculture, offering a pathway towards more resilient and sustainable food production systems worldwide.

References

Amir, K., Hussain, S., Shuaib, M., Hussain, F., Urooj, Z., Khan, W. M., ... & Hussain, F. (2018). Effect of gamma irradiation on OKRA (*Abelmoschus esculentus L*.). Acta ecologica sinica, 38(5), 368-373.

Atteh, A., & Adeyeye, A. (2022). Effect of low gamma irradiation on the germination and morphological characteristics of broad beans (*Vicia faba L.),* mung beans (*Vigna radiata L*.), and peas (*Pisum sativum L*.) seedlings. Natural resources, 13(5), 105-125.

Iqbal, M., Haq, Z. U., Jamil, Y., & Ahmad, M. R. (2012). Effect of presowing magnetic treatment on properties of pea. *International Agrophysics*, *26*(1).

Mahajan, T. S., & Pandey, O. P. (2014). Magnetic-time model at off-season germination. International Agrophysics, 28(1).

Teixeira da Silva, J. A., & Dobránszki, J. (2016). Magnetic fields: how is plant growth and development impacted? Protoplasma, *253*(2), 231-248.

Vashisth, A., & Nagarajan, S. (2008). Exposure of seeds to static magnetic field enhances germination and early growth characteristics in chickpea (*Cicer arietinum L*.). Bioelectromagnetics: Journal of the Bioelectromagnetics Society, The Society for Physical Regulation in Biology and Medicine, The European Bioelectromagnetics Association, 29(7), 571-578.

Verma, A. K., Sharma, S., Kakani, R. K., Meena, R. D., & Choudhary, S. (2017). Gamma radiation effects seed germination, plant growth and yield attributing characters of fennel (*Foeniculum vulgare Mill*.). Int. J. Curr. Microbiol. Appl. Sci, 6(5), 2448-2458.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/03/0625

AN OVERVIEW OF GREEN WEAPONS TO MITIGATE NOISE POLLUTION- A BENEVOLENT CONTRIBUTION TO HUMANKIND

Krishna Biswas[1*] and Divya Kumari[2]

[1]MSc, Department of environment and Sustainable Development,
Central University of Gujarat.
[2]MSc, Department of Chemical Science, Indian Institute of Technology, Jammu.
*Corresponding Email: biswaskrishna8@gmail.com

Abstract
Especially in major metropolitan areas, noise pollution is a serious global health concern. It affects behavior, emotions, and health in addition to getting uncomfortable. Green fibers and plant species are emerging as a promising option for sound absorption, to solve this worldwide problem as noise levels rise. Acute exposure to noise levels above 80–85 dB or prolonged exposure to noise levels above 65 dB can cause cardiovascular problems. Acute noise causes hormonal and neurological reactions that momentarily increase heart rate, blood pressure, and cause vasoconstriction.

Introduction

Noise is a serious environmental pollutant in all societies worldwide. Rapid industrialization and haphazard urbanization have made environmental degradation a major issue. Given the significant harm that noise pollution does to people on a personal and societal level, it might be useful as a guide when developing locations that are susceptible to noise pollution. The quality of life is negatively impacted by noise pollution in both cities and individuals. Despite being unseen and sometimes disregarded, noise pollution has a major negative influence on people's quality of life. Utilizing green materials and plant species is one of the simplest ways to reduce noise pollution. Pollution is defined as 'an undesirable change in physical, chemical and biological characteristics of air, water and land that may be harmful to living organisms, living conditions and cultural assets. According to the Environment Protection Act of 1986, a pollutant is any solid, liquid, or gaseous material that is present in a concentration that may be or is likely to be harmful to the environment. The World Health Organization ranks noise pollution as the third most dangerous type of pollution in urban areas, after air and water pollution. The human ear is capable of picking up noises in the frequency range of roughly 20 to 20,000 Hz.

Effects of noise on human health

- Physical effects: (temporary or permanent hearing loss).
- Physiology effects: (difficulty in breathing, heart beating disorders, the increase of blood pressure, gastrointestinal circulatory disorders, sleep disturbances, irregularity in blood sugar,).
- Psychological effects: (adverse emotions including anger, disappointment, anxiety, and depression behavioral disorders).
- Performance Effects: (drop of reading, learning and work performance, lack of concentration, prevent movements).

Source and Types of Noise Pollution

1. Machinery Noise - Noise from Industrial Plants and Ventilation System Noise. It is responsible for indoor and outdoor noise pollution.

2. Transportation Noise - Road traffic, rail traffic, air traffic and sonic booms. One of the most crucial noise type is urban area and vehicle is the biggest source of noise.
3. Construction Noise - Noise emissions during building construction activities
4. Domestic Noise: -Noise from Leisure Activities and powered machines used in daily activities at home or work place.

Noise level standard in some Countries	Industrial	Commercial	Residential	Silent Zone
Australia (dB)	55- 55	55-45	45-35	45-35
India (dB)	75-70	65-55	55-45	50-40
Japan (dB)	60-50	60-50	50-40	45-35
US EPA (dB)	70-60	60-50	55-45	45-35
WHO (dB)	65-65	55-55	55-45	45-35

Table - Noise level standard in Countries (Source: Chauhan, 2020)

Green materials to mitigate noise pollution

Biodegradable natural fibers like coconut fiber, groundnut shell, and rice husk are becoming more popular as safer substitutes for traditional synthetic materials used for sound absorption because of their detrimental effects on the environment and human health. These materials are safe for human health and the environment, and they absorb sound well. The ISO 10534-2 standard was followed while measuring the sound absorption coefficient.

By lowering noise levels and absorbing harmful gases and dust, the green plants help to stabilize the local climate by regulating temperature and moisture levels and enhancing the metabolism of urban materials.The density and thickness of the green material, along with the existence of an air back chamber, are the main factors that affect sound absorption performance. In the low- to mid-frequency range, thicker materials typically perform better in absorbing sound. Additionally, greater density is linked to superior performance in terms of sound absorption at the same thickness.

Rice Husks

In most Asian countries, rice is the main food and one of the three staple crops in the world, along with wheat and corn. The endosperm, bran, germ, and husk make up the majority of the rice kernel; the latter makes up 20–21% of the overall seed weight. Normally, rice husks are either burned or recycled exclusively for low-cost uses including thermal insulation materials, polymer composites, and concrete composites.

Farmers might benefit from these by-products by using them as green building materials, which would also increase the competitiveness of the construction sector. The best sound absorption performance was found in a polyurethane–rice husk mixture that contained 5% chaff. This study examined the sound absorption performance of polyurethane composites dependent on the amount of rice husk. In conclusion, sound absorption performance improved with an increase in rice husk content. Rice husk significantly affects the pore size and pore size distribution of polyurethane foam, which lowers flow resistance and improves sound absorption performance. This suggests that the addition of rice husk was responsible for the increased sound absorption. The pore size and pore size distribution of polyurethane foam are significantly impacted by rice husk, which lowers flow resistance and improves sound absorption performance. This suggests that the addition of rice husk was responsible for the increased sound absorption.

Two boards composed of a rice husk composite—one with expanded cork granules and the other with recycled rubber granules—were examined by António et al. for their ability to absorb sound. The Noise Reduction Coefficient (NRC) for the expanded cork granules was 0.15 for the 50% rice husk composite and 0.25 for the 75% rice husk composite. The NRC for recycled rubber granules was 0.35 for 50% rice husk and 0.45 for 75% rice husk.

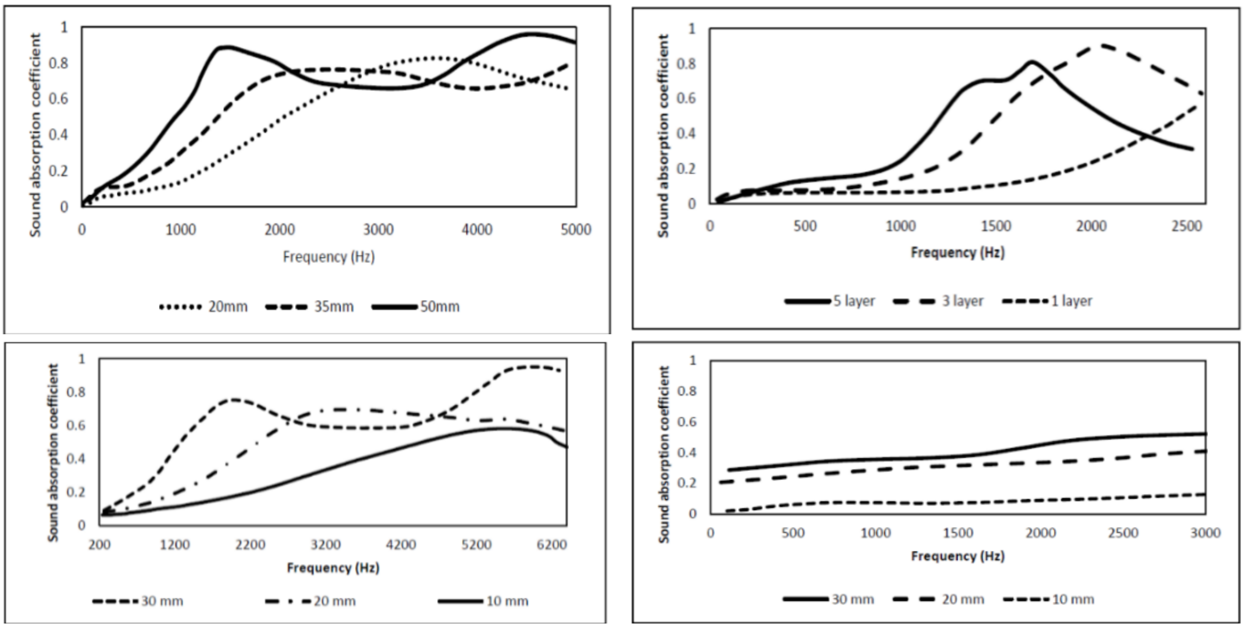


Fig. Sound Absorption curve – 1. Sugar Plam Trunk, 2. Corn Husk,
3. Rice Husk. 4. Peanut shell (Jang, 2023)

Rice Straw

After harvest, the majority of rice straw is burned on-site, which produces greenhouse gases and creates suspended particles that are harmful to the atmosphere and public health. Many studies have been done on the use of rice straw as a building material, particularly for insulation, and to lessen environmental pollutants, especially noise pollution. When combined with other materials, rice straw absorbs sound more effectively than when used alone. The sound absorption properties of composite sound-absorbing materials containing wood particles and rice straw were examined. It was found that the sound absorption coefficient (α) of rice straw composite board outperformed that of other wood-based materials (plywood and fiberboard) as the amount of rice straw increased. Global interest in cutting greenhouse gas emissions has surged as a result of climate change. As a result, there is increasing interest in recycling agricultural waste, and using rice straw as a natural material to absorb sound has quite successful outcomes.

Corn Husk

With a considerable presence in many nations, corn is the most extensively grown cereal crop worldwide. In particular, China and the United States together account for around half of the world's maize market. A maize plant's stover normally consists of 15% hull, 35% leaves and cobs, and 50% stem (stalk). But a sizable amount of corn stover is disposed of as waste.

Only a small amount is utilized as household fuel or animal manure, whereas the majority of the residues are commonly incinerated. Corn husk is considered to be a green sound-absorbing material because it is thinner and lighter than commonly used porous materials. Increasing the air back activity also improved the sound absorption of corn husk at low frequencies. Corn husk has the unique advantage of extremely low production cost. The thickness of corn husk is much thinner than natural fiber felts, such as fique fiber, kapok/hollow polyester fiber, coconut fiber and mineralized fiber. The thickness of bark fabric is comparable to that of maize husk. However, because of the groove structure on the surface of the corn husk, its acoustic absorption coefficient is larger than that of bark cloth. Corn husk also absorbs sound waves more effectively than luffa fiber reinforced composites and felts made of a natural fiber/polypropylene blend. Furthermore, a simple layering technique makes it possible to simply manufacture corn husk into a multi-layer structure.

Sugar Palm Trunk Fibers

The original method of producing palm starch from sugar palm trunks involved shredding them with a machine, which resulted in solid trash that contained fibers. On the other hand, solid waste has a rather high fiber content—roughly 50%. The additional ingredients were removed from these fibers by hand. After being naturally dried, the fibers were then dried for three minutes at 80 °C in an oven to speed up the drying process. The fibers fall within the category of hard fibers. At frequencies of 1000 Hz and higher, samples with a thickness of 50 mm performed the best at absorbing sound when compared to samples with a thickness of less than 0.8. Additionally, the sound absorption coefficient approaches 0.9 in the frequency range of 1200 to 2000 Hz.

Ground Shells

An estimated 26 million hectares are used to raise groundnuts globally, making them a viable agricultural product. An estimated 45 million tons of peanuts are produced annually. Following the addition of peanut shells to impedance tubes of 30, 60, and 90 mm in height, to calculate sound-absorption coefficients. As filling height grew, so did the sound-absorption capacity; noise reduction coefficients (NRCs) for 30-, 60-, and 90-mm heights were 0.23, 0.43, and 0.54, respectively. Furthermore, the average sound-absorption coefficient of peanut shells at 60 and 90 mm heights was 0.9 for noises higher than 2,000 Hz. The significant added value of powdered nut shells could be attributed to their ability to absorb sound.

Areca Nut Shells Fibers with Polyvinyl Alcohol Composite

Areca nut shell fibers (ANS) mixed with polyvinyl alcohol glue were used to construct sound-absorbing composites in an effort to provide a sustainable and eco-friendly substitute for traditional synthetic materials. The efficiency of the composites over various frequency ranges was assessed by measuring the sound absorption coefficient (SAC) using the impedance tube method. The findings show that the composite's thickness greatly improves sound absorption, especially at low frequencies (1,500–2,500 Hz). The best sound absorption characteristics were shown by composites with a 30 mm fiber length at 0.90 above 1,600 Hz (ANS-T30-L30). Additionally, SAC's behavior changed when fibers of varying lengths were blended.

Plant Species to mitigate noise pollution

When there are adequate green areas, plants may significantly improve urban ecosystems by reducing noise. By lowering noise levels and balancing the local climate by regulating temperature and moisture, the green plants absorb harmful gases and dust while also enhancing the metabolism of urban materials. The sound emitted by the trunk, branches, leaf area, bark, plant canopy, and foliage of the vegetation can primarily reduce traffic noise. Through energy absorption, refraction, and reflection, trees and plants can reduce sound levels. According to a study by Zhi, Zhu, and Jiani (2010), the plant's ability to reduce noise is related to the shape of its leaves. With a minimum planting area of 5 meters, the "evergreen" plants have larger, harder-textured, longer, intensive leaf branches, and apical tissue that should reach the ground. Plant belt placement will be more effective if it is as close to the noise source as possible. In terms of TSP removal (total suspended particle), roadside vegetation stands can significantly lower noise levels and traffic-induced air pollution in and around urban areas. The percentage of TSP removed has a negative correlation with shelterbelt porosity and a positive correlation with canopy density. Rapid growth, a high biomass and leaf count for fuel and fodder, the capacity to fix atmospheric nitrogen, and the ability to withstand water stress and temperature extremes are all necessary for plants to effectively reduce pollution. Trees with robust, meaty leaves that can tolerate vibration and have flexible petioles are appropriate. Tree attributes, such as height, crown width, number of branches, leaf kinds, leaf location relative to noise direction, and plant density, all have an impact on noise attenuation.

A) Alstonia scholaris

B) Cassia fistula

C) *Nerium oleander*

D) *Hibiscus × rosa-sinensis*

Source: Camera Captured

Obtainable plant species for attenuation

The absorption coefficient factor to reduce noise in plants is the leaf area density and leaf orientation angle of various plant species, such as *Geranium zonale, Hedera helix* (green ivy), *Pieris japonica*, Summer *Primula vulgaris* (summer primrose), and Winter Primula vulgaris (winter primrose). *Adhatoda Vasica, Adhatoda Zeylancia*, and *Terminalia arjuna* have an average sound attenuation (dBA) of 9.9. Nelotica Acacia 7.4 (dBA) by *Cabada fruticosa, Prospis cineraria, Eichhornia crassipes*, and *Azadirachta* indica. In the investigation of the spectral properties of traffic noise attenuation by plant belts in Delhi, *Datura Alba, Acacia Senegal, Accacia auriculata, Cassia italic, Prosopis cineraria*, and Mimosa hamate discovered 9.4 (dBA) (2005). The physical road traffic noise reduction by studying in Soil effect, Trunks and Crown scattering. by expanding the trunk diameter and reducing the distance between trees. *Alstonia scholaris, Azadirachta indica, Melia azedarach, Butea monosperma*, *Grevillea pteridifolia, Grevillea Robusta, Tamarindus indica*, and Terminalia arjuna are among the trees whose thicker branches and trunks deflect or reflect the sound wave. Evergreen tree belts of Bambusa dolichoclada, Garcinia subelliptica, F. microcarpa, Gardenia jasminoides, and Nerium indicum were examined for their ability to reduce noise. In 2005, Fang and Ling conducted research on *Nageia nagi, Pongamia pinnata, Erythrina variegate, Senna siamea, Araucaria heterophylla, Hibiscus tiliaceus*, and *Livistona chinensis in* relation to Ravenala madagascariensis. A noise meter was used to measure the noise level at several locations within the tree belts after a point source of noise was placed in front of them. The tree belts' height, width, length, and visibility are all crucial elements in noise suppression. They found that visibility and relative attenuation had a negative logarithmic relationship, but the width, length, or height of the tee belts had a positive logarithmic association with relative attenuation.

Conclusion and Recommendations

Green materials are a preferred choice for many applications since they are safe for human use and have low toxicity. Their biodegradability lessens the effects on the environment and encourages sustainability. Green materials are therefore very sought-after for their ability to absorb sound. Noise reduction is efficiently improved by thick sound-absorbing material, which offers several areas for sound energy to enter. This suggests that there are a lot of opportunities to investigate and make use of various environmentally beneficial materials because of their capacity to absorb sound, increasing the number of solutions for dealing with noise pollution. However, their continuous supply is necessary for the commercial application of green materials as sound absorbers. Green materials are therefore highly valued for their ability to absorb sound. Noise reduction is efficiently improved by thick sound-absorbing material, which offers several areas for sound energy to enter. This suggests that there are a lot of opportunities to investigate and make use of various environmentally beneficial materials because of their capacity to absorb sound, increasing the number of solutions for dealing with noise pollution. However, their continuous supply is necessary for the commercial application of green materials as sound absorbers. Our environment will eventually become greener and pollution-free if decorative plants with pollution-mitigating qualities are incorporated into the landscape design. Numerous plant species, such *as Nerium indicum* (Oleander, Kaner), *Justicia adhatoda* (Vasa, Basak, Adusi), *Hibiscus rosa-sinensis* (China rose, Gurhal, and Java), and *Datura metel* (Datura). Trees that are appropriate for Indian topography for absorbing noise pollution in urban environments include *Terminalia arjuna* (Arjun), *Tamarindus indica* (Imli), *Cassia fistula* (Amaltas, Golden Shower Tree), and *Alstonia scholaris* (Devil's tree, Chitvan, Saptaparna), among others. Living plant barriers can be used as a noise reduction technique since vehicle density, which rises in tandem with population growth, is uncontrollable

Living plant barriers can be used as a noise reduction technique since vehicle density, which rises in tandem with population growth, is uncontrollable. using roof garden techniques and the use of plant material on building surfaces. In the long term, plants and green materials that can reduce pollution will help to maintain a green and pollution-free environment. Plants and green materials having pollution mitigating ability in the landscape plan will help our environment to green and pollution free in the long run.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/04/0625

SUSTAINABLE ALTERNATIVES TO FISH MEAL AND FISH OIL IN AQUACULTURE

Sarvendra Kumar[1*], Showkat Ahmad Dar[1], Susmita Rani[1], Md Aman Hassan[2] and Aman Divakar[3]

[1]Assistant Professor, Department of Fish Physiology and Biochemistry,
College of Fisheries Kishanganj, 855107
[2]Assistant Professor, Department of Fish Processing Technology,
College of Fisheries Kishanganj, 855107
[3]Assistant Professor, Department of Fish Biotechnology,
College of Fisheries Kishanganj, 855107
*Corresponding Email: sarvo0203@gmai.com

Introduction

Aquaculture is growing rapidly as a global food-producing sector and continues to flourish day by day. Fish meal represents 50% to 70% of the total material in fish feed (Jannathulla *et al.*, 2019). It is highly considered a feed protein source since it has an excellent composition of amino acids and is easy to digest (Olsen *et al.*, 2012). Moreover, the feed cost is 60% to 70% of an aquaculture farm's total operating expenses. In contrast, the decreasing fish catches (Macusi *et al.*, 2022) and consistent growth in fishmeal consumption is creating a gloomy future for the aquaculture industry, although not if there is a paradigm shift toward the utilization of non-fish components for fish feed production. Aquaculture is projected to expand with increased demand for aquatic products, leading to higher fishmeal consumption. Fish oil (FO) and fishmeal (FM) could increase pressure on the diminishing stocks of marine fish resources (Aladetohun and Sogbesan, 2013). In recent years, fishmeal prices have climbed globally by more than two-fold (FAO, 2013). FM and FO-derived mainly from wild-caught fish-raises significant sustainability concerns. Overfishing, environmental degradation, and rising costs have driven the search for more sustainable and economically viable alternatives. Replacing fish meal and fish oil with sustainable alternatives is not just an environmental necessity-it is also a strategic move to ensure the long-term growth, cost-effectiveness, and social acceptability of aquaculture worldwide. Therefore, there is an urgent need to find an alternative protein source to replace fishmeal. Several sources of plant protein, single-cell protein, and animal protein have partially or entirely replaced the more expensive fishmeal. Animal protein sources have traditionally been regarded as the best alternative to replace fishmeal in the formulation of fish meals owing to their higher protein and fat content, superior essential amino acids, and excellent palatability (Yigit *et al.*, 2006). On the other hand, plant ingredients that contain high protein content, high digestibility of crude protein, and low antinutritional components can replace fishmeal as a substitute protein source for fish (Dersjant, 2021). This article explores various innovative and sustainable substitutes that are being adopted or developed to replace FM and FO in aquafeeds, with a focus on their efficacy, availability, and environmental impact.

Plant-Based Proteins

Naturally derived FM is at risk due to an increase in its demand, unsustainable practices, and price. Plant protein sources are suitable due to their widespread availability and low cost. Plant-derived ingredients, especially soybean meal, corn gluten, pea protein, and canola meal, are the most widely used FM alternatives. They are readily available, cost-effective, and rich in protein.

However, limitations such as the presence of anti-nutritional factors (ANFs), imbalanced amino acid profiles, and lower digestibility. These unfavorable characteristics make them less suitable for feed as compared to FM. Thus, these potential challenges and limitations associated with various plant proteins have to be overcome by using different methods, i.e. enzymatic pretreatments, solvent extraction, heat treatments and fermentation. Today soyabean meal is the most used protein source in aquafeed globally. Inclusion in aquaculture diet ideal due to it protein content, balance amino acid profile, high level of palatability and digestibility for most of the fish and shrimp species. Plant based protein utilization increased over the past two decades.

Insect Meals

The increasing demand for sustainable and cost-effective protein sources in aquaculture has led to growing interest in insect meal as a promising alternative to FM. Insects, particularly species like the black soldier fly (*Hermetia illucens*), mealworms (*Tenebrio molitor*), and housefly (*Musca domestica*) larvae, are naturally part of many fish diets in the wild and offer several advantages for modern aquafeed formulations. They have high protein and fat content, can be grown on organic waste, and have a low environmental footprint. Studies show promising results in terms of growth performance and health in fish like tilapia, salmon, and catfish when insect meals partially or fully replace FM. Insect meals are rich in high-quality protein (up to 40–70% crude protein depending on species and processing) and contain essential amino acids comparable to FM. They also provide beneficial lipids, including medium-chain fatty acids like lauric acid, which possess antimicrobial properties.

Microbial Proteins

Microbial proteins, also known as single-cell proteins (SCP), are derived from microorganisms such as bacteria (Methylobacterium, *Methylococcus capsulatus*, and *Rhodobacter* species), yeast (*Saccharomyces cerevisiae*, *Candida utilis)*, fungi (*Fusarium venenatum*), and microalgae (*Chlorella, Spirulina, Nannochloropsis, Schizochytrium*). Single-cell proteins (SCP) provide high-quality protein with a well-balanced profile of essential amino acids. Algae, particularly microalgae like *Schizochytrium* and *Nannochloropsis*, are rich in omega-3 fatty acids and are considered effective FO alternatives. These protein-rich biomass sources are gaining attention as innovative and sustainable alternatives to FM in aquaculture due to their high nutritional value, fast production rates, and minimal environmental footprint. High Nutritional Value: SCPs typically contain 50-75% protein with essential amino acids similar to fish meal. Some SCPs also act as functional feed additives, improving gut health, immunity, and feed efficiency. Large-scale production remains expensive compared to conventional protein sources, though costs are declining with technological advancements.

Rendered Animal By-products

Rendered animal by-products-such as poultry by-product meal (PBM), meat and bone meal (MBM), blood meal, and feather meal-have emerged as practical and protein-rich alternatives to fish meal (FM) in aquaculture feeds. These ingredients can successfully replace FM in various aquafeeds, though concerns over disease transmission, consumer acceptance, and regulatory issues must be carefully managed.

- **Poultry By-product Meal (PBM):** 55–70% crude protein and a good amino acid profile, especially rich in methionine and lysine.
- **Blood Meal:** Protein content up to 90% with high digestibility, but usually deficient in isoleucine.

- **Meat and Bone Meal (MBM):** Protein-50–55% and minerals such as calcium and phosphorus, useful in balanced formulations.
- **Feather Meal:** Protein 80–90% but low in digestibility.

Fermented and Bio-Processed Ingredients

Fermentation and bio-processing technologies are increasingly being used to convert agricultural residues, plant materials, and fish/agro-waste into nutritionally enhanced, digestible, and cost-effective feed ingredients. Fermentation can enhance the nutritional value of plant and waste materials by improving digestibility and reducing ANFs. Fermented soybean meal, fermented agricultural by-products, and silage from fish waste or crop residues have shown potential as functional feed ingredients. Fermented feed ingredients are derived from microbial processing of raw materials-such as soybean meal, maize cob, cassava peel, rice bran, or fish waste—using bacteria, fungi, or yeast. This process improves nutritional quality by:

- Breaking down complex carbohydrates and ANFs
- Enhancing protein digestibility and amino acid availability
- Enriching feed with probiotics, enzymes, and bioactive compounds

Oil Alternatives

Fish oil (FO) is widely used in aquaculture due to its high content of essential long-chain omega-3 fatty acids particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). However, due to overfishing, limited supply, high cost, and sustainability concerns, the aquafeed industry is actively exploring alternative oil sources to replace or partially substitute fish oil without compromising fish health, growth, or nutritional value. Plant oils such as canola, flaxseed, and soybean oil are widely used to replace FO due to their availability. However, they lack long-chain omega-3 fatty acids (EPA and DHA), essential for fish health and human nutrition. Algal oils, particularly from marine microalgae, offer a direct and sustainable source of EPA and DHA.

Oil use in aquaculture Alternatives to Fish Oil

Plant-Based Oils: Soybean oil, canola oil, linseed (flaxseed) oil, sunflower oil, palm oil.

- Cost-effective and widely available
- Rich in omega-6 and omega-9 fatty acids (especially linoleic and oleic acids)
- Limitations: Lack EPA and DHA (omega-3 LC-PUFAs)

Algal Oil (Microalgae): *Schizochytrium*, *Nannochloropsis*, *Crypthecodinium*

- Rich in DHA and sometimes EPA
- Limitations: Higher cost than fish oil or plant oils

Insect-Derived Oils: Black soldier fly (BSF), produce fat that can be extracted as oil.

- Sustainable and produced using organic waste
- Limitations: Low omega-3 content

Animal Fat and Poultry Oil: Poultry oil, tallow

- High energy value and cost-effective
- Compatible with carnivorous species like catfish or salmon
- Limitations: Lacks omega-3 fatty acids

Conclusion

Transitioning from traditional fish meal and fish oil to sustainable alternatives is essential for the long-term viability of aquaculture. While each substitute has its own challenges, combinations of these ingredients-optimized through precision formulation and modern feed technology can provide balanced nutrition, reduce environmental impact, and ensure food security. Continued research, policy support, and industry collaboration will be key to accelerating the adoption of these sustainable solutions.

References

Aladetohun, N. F., & Sogbesan, O. A. (2013). Utilization of blood meal as a protein ingredient from animal waste product in the diet of Oreochromis niloticus. *International journal of fisheries and aquaculture*, 5(9), 234-237.

Dersjant-Li, Y. (2021). The use of soya protein in aquafeeds. *Oilseeds Focus*, 7(2), 29-31.

Jannathulla, R., Rajaram, V., Kalanjiam, R., Ambasankar, K., Muralidhar, M., & Dayal, J. S. (2019). Fishmeal availability in the scenarios of climate change: Inevitability of fishmeal replacement in aquafeeds and approaches for the utilization of plant protein sources. Aquaculture Research, 50(12), 3493-3506.

Macusi, E. D., Liguez, C. G. O., Macusi, E. S., Liguez, A. K. O., & Digal, L. N. (2022). Factors that influence small-scale Fishers' readiness to exit a declining fishery in Davao Gulf, Philippines. *Ocean & Coastal Management*, 230, 106378.

Olsen, R. L., & Hasan, M. R. (2012). A limited supply of fishmeal: Impact on future increases in global aquaculture production. *Trends in Food Science & Technology*, 27(2), 120-128.

Yigit, M., Erdem, M., Koshio, S., Ergün, S., Turker, A., & Karaali, B. (2006). Substituting fish meal with poultry by-product meal in diets for black Sea turbot Psetta maeotica. *Aquaculture Nutrition*, 12(5), 340-347.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/05/0625

REVIVING PULSES: A STRATEGIC PATHWAY TO SUSTAINABLE AGRICULTURE AND NUTRITIONAL RESILIENCE IN INDIA

Pratibha Sharma[1*] and Jeenia Thalyari[2]

[1]Faculty of Agricultural Sciences, DAV University, Jalandhar, Punjab
[2]Faculty of Agricultural Sciences, DAV University, Jalandhar,
[1]Faculty of Agricultural Sciences, DAV University, Jalandhar
[*]Corresponding Email: preety8296@gmail.com

Pulses are one of the major food crops grown and consumed globally as well as in India. Due to their low carbon and protein rich nature, pulses fulfil the protein requirements of balanced diet, especially in the vegetarian scenario. Pulses are rich in dietary fibre and micronutrients such as iron, folate, magnesium, potassium and zinc. The low glycemic index, naturally low cholesterol levels and gluten- free nature of pulses make them ideal for cardiovascular and gut health. Pulses are nitrogen-fixing leguminous crops that enrich soil nitrogen by fixing atmospheric nitrogen into ammonia which is utilized by plants. They are water efficient crops as these require significantly less amount of water for their cultivation as compared to cereal crops like rice, wheat and vegetable crops. Pulses not only enhance biological diversity in the soil but also improve the soil structure by promoting soil aeration, water retention, and reduction of erosion with their deep root system.

Globally, India accounts for 29 per cent of the pulse production area while domestically it covers 37 per cent of area among other crops and hence pulses account for large financial benefits for the country. The productivity of pulses in India was 932 kg/ha during 2021-22 which has improved significantly over past five years. However, in the present scenario, production of pulses does not meet the demand to fulfil the population requirement. It is estimated that 39 million tonnes of pulses are needed by 2050 to fulfil the population increase. Therefore, it is essential to forecast pulse production and formulate policies which use hybrid models to predict pulse production. The study forecasts 26 million tonnes of pulses by 2026. To meet demand by 2050, it must expand 2.2% annually, reducing dependence on imports and moving towards self-sufficiency.

Pulses are cultivated year-long in all three seasons in India, among which Pigeon pea (Arhar), Urd (Blackgram), Moong (Greengram), Lobia (Cowpea), Kulthi (Horsegram) and Moth are grown in kharif season; Gram, Lentil, Peas, Lathyrus and Rajmash are grown in rabi and Greengram, Blackgram and Cowpea are grown in the summer season. Rajasthan, Madhya Pradesh, Maharashtra, Uttar Pradesh, and Karnataka are the leading pulse-producing states in India. Madhya Pradesh contributes 22% of the total pulse production, followed by Maharashtra and Rajasthan at 16% each, and Uttar Pradesh at 10%. Due to growing self-sufficiency in pulse production and a continuously increasing population, per capita availability of pulses has shown a modest upward trend. The daily per capita availability increased from 43 grams in 2013 to a provisional level of 45 grams in 2021. Similarly, annual per capita availability rose from 15.8 kg in 2013 to 16.4 kg in 2021, with a noticeable improvement recorded during 2017–18. In alignment with the Food Security Act (FSA), 2013, which aims to ensure nutritional security particularly for the vegetarian population the target per capita availability of pulses is set at 55 grams per person per day, equivalent to 20 kg per person per year.

Despite accounting for 25% of global pulse production, India's share in its own total food grain output has declined from 16% in 1950 to 8% in 2022-23. This substantial demand–supply mismatch is expected to widen further due to fluctuating production levels. Additionally, the per capita availability of pulses has been decreasing, as government policies continue to prioritize the cultivation of staple crops such as wheat and rice over pulses. The current production levels are insufficient to meet the rising domestic demand, necessitating significant pulse imports. Given this supply gap, pulses have gained prominence in government initiatives aimed at doubling farmers' income by promoting crop diversification and shifting focus from traditional cereal-based agriculture.

The future agricultural operations are likely to be highly skilled and competitive. The serious challenges to the workforce/youth of these resource poor and rainfed regions viz. lack of skill in scientific crop cultivation, repair and maintenance of farm machineries and implements, production of quality seeds, primary processing, value addition, modern animal husbandry, poor infrastructure (irrigation, go downs/ware houses, trading centres) and organized pulse markets etc. have been considered by the government while formulating the strategy and roadmap to increase the production of pulses. The poor nutritional status of the population also remains a significant challenge, particularly among low-income and small-scale households, with long-term adverse effects on economic development. To address this issue, the government has adopted nutrition-sensitive agricultural interventions, emphasizing pulse crops due to their high nutritional value. Pulses are rich sources of essential vitamins, micronutrients, and protein, making them vital for achieving nutritional security. Moreover, pulses offer a favorable environment for promoting dietary and production diversity, contributing to the fight against hunger and malnutrition at the national level.

The Government of India has taken several important steps to achieve self-sufficiency in pulse production. Recently, Finance Minister Nirmala Sitharaman announced a six-year "Pulses Mission" in the 2025-26 Union Budget, aiming for "Aatmanirbharta (self-reliance) in key Pulses" like tur (pigeon pea), urad (black gram), and masoor (lentils) by 2029-30. Under this mission, state agencies will procure pulses from farmers at the Minimum Support Price (MSP), ensuring fair prices and encouraging increased production. Additionally, the Department of Agriculture and Farmers' Welfare is promoting the National Food Security Mission (NFSM)-Pulses program across 28 states and 2 Union Territories (Jammu & Kashmir and Ladakh). This initiative focuses on expanding cultivation areas and increasing productivity. The strategy also involves expanding pulse cultivation, especially in rice fallow areas and non-traditional pulse-growing regions, while boosting productivity through the adoption of high-yielding varieties, intercropping practices, and cluster-based demonstrations. Additionally, the mission seeks to reinforce seed systems, provide technical and agronomic support, and establish robust market linkages alongside price assurance mechanisms like the Price Support Scheme (PSS). By aiming to reduce import dependency and strengthen domestic production, the mission plays a vital role in enhancing nutritional security and promoting farmer welfare, aligning with the broader goal of building an Aatmanirbhar Bharat. The renewal of pulses cultivation through future policy interventions is expected to bring significant positive changes to the lives of farmers, especially those in rainfed and resource-poor regions. Upcoming government strategies will likely focus on expanding support under existing schemes such as the National Food Security Mission (NFSM), promoting the use of high-quality seeds, biofertilizers, and climate-resilient technologies. These policies will encourage farmers to shift from water-intensive crops to pulses, fostering sustainable agricultural practices and conserving natural resources. With assured procurement at Minimum Support Prices (MSP) and improved market infrastructure, farmers will be able to secure better income and price stability. Future policies will also emphasize capacity building through training, extension services, and greater access to institutional credit and crop insurance. As these initiatives take effect, it is anticipated that the area and productivity of pulses will increase, rural livelihoods will strengthen, and overall agricultural resilience will improve. Additionally, these measures will support national goals of nutritional security and soil fertility through crop diversification and enhanced biological nitrogen fixation.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed monthly newsletter

Article ID : 05/VI/06/0625

BIOFORTIFICATION: AN ECOLOGICAL APPROACH TO ADDRESSING HIDDEN HUNGER

Soumen Mandal*and Ankan Ghosh
Student, Bachelor of Science (Hons.) Agriculture,
Brainware University, Barasat, Kolkata, West Bengal, India, 700125
*****Corresponding Email: soumenmandal574@gmail.com

Abstract
Micronutrient deficiencies, sometimes known as hidden hunger, affect about two billion people globally, particularly in developing countries. Enhancing the nutrient content of staple crops by plant breeding and agronomic techniques, or biofortification, is becoming a viable and affordable way to address this worldwide issue. The methodology, advantages, drawbacks, and success stories of biofortification are examined in this article, which highlights its potential as a long-term strategy to enhance nutritional security, particularly in rural and resource-poor areas.

Keywords: Biofortification, Hidden Hunger, Micronutrient Deficiency, Sustainable Agriculture

Introduction

Hidden hunger is a secret problem that deprives communities of essential vitamins and minerals, even when calorie needs are met. It reduces productivity, damages immunity, raises maternal and infant mortality, and hinders cognitive development. Particularly in rural areas, traditional interventions such as industrial fortification and dietary supplements have limitations in terms of cost, coverage, and compliance (Ofori *et al*., 2022). By enhancing food crops' nutritional value at the source, biofortification fills in these gaps.

What is Biofortification?

Increasing the concentration and bioavailability of vital micronutrients in crops is known as biofortification, and it is accomplished by:

1. **Traditional Plant Breeding**: Choosing and crossing cultivars that are naturally high in nutrients.
2. **Agronomic Biofortification:** Fertilizing crops with nutrient-rich fertilizers.
3. **Transgenic Techniques:** When natural variation is inadequate, genes that synthesize micronutrients are introduced (Saltzman *et al*., 2013). Biofortified crops, as opposed to post-harvest fortification, provide nutrients directly through daily diets without necessitating infrastructure or dietary changes.

Verified Achievements

The practical efficacy of biofortification has been proven by numerous studies and initiatives: In Uganda and Mozambique, **Orange-fleshed sweet potatoes (OFSP)**, which are high in vitamin A, have greatly enhanced children's health (Low *et al*., 2007). **Iron-rich beans** have enhanced the iron status of Rwandan women (Ofori *et al*., 2022).

Zinc-enriched rice and wheat in South Asia and **provitamin A maize** in Zambia and Nigeria have demonstrated quantifiable gains in nutrient uptake and health outcomes (Saltzman *et al*., 2013).
As of 2017, about 33 million individuals were consuming biofortified foods in Latin America, Asia, and Africa (Ofori *et al*., 2022).

Benefits Over Conventional Approaches:

Cost-effective: Long-term nutritional benefits can be obtained with a single investment in seed breeding. **Wide-ranging:** focuses on underprivileged, rural communities without access to supplements and fortified foods.

Sustainable: Adapts to current agricultural and food systems without incurring ongoing expenses (Bouis *et al*., 2011). To reach a wider audience, biofortified crops can also be incorporated into government procurement programs, school meals, and public nutrition initiatives.

Difficulties and Reflections:

Though promising, biofortification has challenges:

Policy Barriers: Particularly regarding GM crops in areas without biosafety frameworks.

Consumer Acceptability: Color or taste variations may necessitate awareness campaigns. Distribution systems must guarantee timely and fair availability of high-quality biofortified seeds (Saltzman *et al*., 2013). Colour or taste variations may call for awareness campaigns; policy barriers especially around GM crops in areas lacking biosafety frameworks.

Scaling biofortification internationally requires ongoing stakeholder collaboration, including from farmers, nutritionists, legislators, and breeders.

Conclusion

A workable, scientifically supported answer to the persistent problem of hidden hunger is provided by biofortification. It works well in a variety of agroecological and cultural contexts and supports other interventions. One seed at a time, investing in biofortified crops can contribute to the creation of a healthier, more resilient population as we work toward the 2030 Sustainable Development Goals.

References

Bouis, H. E., *et al*. (2011). Biofortification: A new tool to reduce micronutrient malnutrition. Food and Nutrition Bulletin, 32(S1), S31–S40.

Low, J. W., *et al*. (2007). Vitamin A intake and serum retinol concentrations increased among children in rural Mozambique. The Journal of Nutrition, 137(5), 1320–1327.

Meenakshi, J. V., *et al*. (2010). How cost-effective is biofortification in combating micronutrient malnutrition? World Development, 38(1), 64–75.

Nestel, P., *et al*. (2006). Biofortification of staple food crops. The Journal of Nutrition, 136(4), 1064–1067.

Ofori, K. F., Antoniello, S., English, M. M., & Aryee, A. N. A. (2022). Improving nutrition through biofortification–A systematic review. Frontiers in Nutrition, 9, 1043655. https://doi.org/10.3389/fnut.2022.1043655

Pfeiffer, W. H., & McClafferty, B. (2007). Biofortification: Breeding micronutrient-dense crops. Journal of the Science of Food and Agriculture, 87(1), 129–139.

Qaim, M., Stein, A. J., & Meenakshi, J. V. (2007). Economics of biofortification. Agricultural Economics, 37(S1), 119–133.

Saltzman, A., Birol, E., Bouis, H. E., *et al*. (2013). Biofortification: Progress toward a more nourishing future. Global Food Security, 2(1), 9–17. https://doi.org/10.1016/j.gfs.2012.12.003

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/07/0625

BIOFORTIFICATION IN AGRICULTURAL CROPS – A WAY TO FIGHT MALNUTRITION

Priyanka Chand[1]* and D.V Singh[2]

[1]Research Scholar, ITM University, Gwalior, M.P.
[2]Principal Scientist (Agricultural Extension), ICAR-ATARI, Patna, Bihar
Corresponding Email: priyankachand.pc28@gmail.com

Introduction

Malnutrition remains a major global health challenge, particularly in developing countries where staple food crops form the bulk of the daily diet. Deficiencies in essential micronutrients like iron, zinc, vitamin A, and iodine—often termed "hidden hunger"—impair growth, cognitive development, immunity, and productivity. Traditional approaches such as food supplementation and industrial fortification have limitations in reach, cost, and sustainability. In this context, biofortification, the process of increasing the nutrient content of crops through conventional breeding or modern biotechnology, emerges as a promising, sustainable, and cost-effective strategy to combat malnutrition at the grassroots level.

What is Biofortification?

Biofortification refers to the enhancement of the nutritional quality of food crops during their growth phase, rather than through post-harvest fortification. It involves increasing the density of vitamins and minerals in a crop’s edible parts, such as grains, roots, or tubers. Biofortification can be achieved through:

- Conventional breeding (selecting nutrient-rich varieties)
- Genetic engineering (transgenic approaches)
- Agronomic biofortification (application of mineral fertilizers or foliar sprays)

Key Micronutrients Targeted by Biofortification

1. Iron (Fe): Crucial for oxygen transport and energy metabolism. Its deficiency leads to anemia.
2. Zinc (Zn): Important for immune function, growth, and development.
3. Vitamin A (β-carotene): Essential for vision, immunity, and cellular health.
4. Iodine and Selenium: Though less common in crop biofortification, these are vital for thyroid function and antioxidant defense.
5. Folic Acid and Amino Acids: Targeted in newer biofortification programs for enhancing maternal and child health.

Examples of Biofortified Crops

Crop	Nutrient Enhanced	Varieties Developed	Impact Area
Rice	Iron, Zinc	DRR Dhan 45 (Zn), BRRI dhan 62 (Zn)	India, Bangladesh
Wheat	Zinc	WB 02, HPBW-01 (India)	India
Maize	Provitamin A	Orange Maize (QPM - Quality Protein Maize)	Africa

Crop	Nutrient Enhanced	Varieties Developed	Impact Area
Sweet Potato	Vitamin A	Orange-Fleshed Sweet Potato (OFSP)	Sub-Saharan Africa
Pearl Millet	Iron, Zinc	Dhanashakti	India
Cassava	Vitamin A	Yellow Cassava	Nigeria, DR Congo

Methods of Biofortification

1. Conventional Plant Breeding: Uses genetic variability to crossbreed high-yielding varieties with nutrient-rich lines. Example: Dhanashakti pearl millet with high iron and zinc content.
2. Genetic Engineering: Introduces specific genes to enhance nutrient synthesis. Example: Golden Rice, engineered to produce β-carotene (a precursor of vitamin A).
3. Agronomic Biofortification: Application of micronutrient-rich fertilizers to soil or foliar sprays. Rapid and cost-effective, though effects may not be as long-lasting as genetic approaches.

Benefits of Biofortification

1. Sustainable Solution: Once bred, seeds can be distributed widely with minimal recurring cost.
2. Farmer-Friendly: Often integrated into high-yielding and climate-resilient varieties.
3. Rural Reach: Targets populations that may not access fortified foods or supplements.
4. Child and Maternal Health: Improves outcomes for vulnerable groups.

Challenges in Biofortification

1. Limited Genetic Variability: For some crops, natural variation in nutrient content is low.
2. Consumer Acceptance: Changes in taste, texture, or color (e.g., orange maize) may deter adoption.
3. Market Integration: Lack of incentives and certification mechanisms for biofortified crops.
4. Regulatory Hurdles: Especially for transgenic crops like Golden Rice.

Global Initiatives Promoting Biofortification

1. HarvestPlus Program (CGIAR): Pioneering research and dissemination of biofortified crops globally.
2. Indian Council of Agricultural Research (ICAR): Developing and releasing biofortified varieties under the National Agricultural Research System (NARS).
3. National Biofortification Network: A platform for collaboration among breeders, nutritionists, and policymakers.
4. FAO and WHO: Recognizing biofortification as part of food-based dietary diversification strategies.

Biofortification and Sustainable Development Goals (SDGs)

Biofortification contributes significantly to several SDGs:

- SDG 2: Zero Hunger – by improving food quality and security.
- SDG 3: Good Health and Well-being – by reducing micronutrient deficiencies.
- SDG 12: Responsible Consumption – by promoting naturally nutrient-rich crops.
- SDG 13: Climate Action – biofortified varieties are often stress-tolerant and climate-resilient.

Way Forward

To fully realize the potential of biofortification:

- Public awareness and education campaigns are essential to drive adoption.
- Policy support through inclusion in food safety and nutrition guidelines.
- Research investment in multi-nutrient biofortification and crop bioavailability.
- Integration with national nutrition programs, such as mid-day meals and ICDS.

Conclusion

Biofortification is a revolutionary approach to address the pervasive issue of micronutrient deficiencies in a sustainable and farmer-friendly manner. By enriching staple crops that form the dietary backbone of millions, it offers a scalable and cost-effective tool to combat malnutrition at its root. Strategic policy integration, coupled with scientific innovation and community engagement, can make biofortification a cornerstone of global nutrition security.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/08/0625

SAFEGUARDING SHRIMP FARMS: A COMPREHENSIVE GUIDE TO BIOSECURITY

Prasanna Laxmi U*, **Sirisha H., Kranthi Kumar D, Aitwar Vaijnath S, Usha A, Chamundeshwari B, Nikhil K, Neha P and Kishore Kumar M**

College of Fishery Science, Narasapuram, West Godavari (Andhra Pradesh)- 534 275
*Corresponding Email: uplaxmi284@gmail.com

Abstract
Aquaculture plays a vital role in feeding the world and balancing the seafood demand. However, this growth brings increased risks of disease outbreaks that can harm farmed fish, shrimp, mollusks, and other aquatic species. Biosecurity—practices that prevent the entry and spread of harmful pathogens—is now essential for safe and sustainable seafood production. With over 500 species farmed worldwide, threats like poor farm design, overcrowding, climate change, and global trade increase vulnerability. Often, harmful organisms remain hidden until stress or environmental changes trigger outbreaks. Modern biosecurity uses barriers, sanitation, immune-boosting practices, and technologies like AI and real-time monitoring to detect and manage risks early to combat them. Though these systems require investment, they help protect aquatic life, ensure food safety, and support farmer livelihoods. Moving forward, stronger global cooperation, better regulations, and continued innovation will be key to securing aquaculture's future.

Key words: Aquaculture, Biosecurity, Disease Outbreaks.

What is Biosecurity?

Biosecurity refers to the strategic implementation of practices, protocols, and policies designed to prevent, control, and eradicate the introduction and spread of infectious agents. Biosecurity in shrimp aquaculture is a critical yet often underappreciated component of sustainable and profitable farming. Unlike treatment methods, which respond to outbreaks after damage is done, biosecurity is a preventive shield. It is a farm's first line of defense — keeping diseases out, minimizing their spread, and avoiding cross-contamination. Despite its proven role in mitigating disease outbreaks and safeguarding animal and public health, biosecurity is frequently overlooked by small and marginal shrimp farmers, particularly in developing countries. Many stakeholders perceive biosecurity protocols as cost-prohibitive, and they lack awareness of the substantial ecological and economic advantages of sustainable aquaculture systems.

A significant barrier to the implementation of biosecurity measures is the lack of scientific literacy and institutional support among farming communities. In many regions, the absence of standardized operational protocols, weak legal frameworks, and poor enforcement mechanisms further complicates the situation. As a result, shrimp farms remain highly susceptible to pathogen introduction and transmission, leading to the occurrence of disease outbreaks that decrease productivity and income. Nevertheless, when effectively adopted, biosecurity strategies can enhance production efficiency, reduce losses due to disease, and ultimately contribute to greater financial stability within the aquaculture sector.

How do pathogens enter and spread on the farm??

1. Entry into the Farm

- Diseases can be unknowingly introduced when infected broodstock or seed are brought in from hatcheries that are not certified.

- People, tools, and vehicles may carry harmful germs into the farm through dirty shoes, hands, or equipment.
- Using water from rivers or nearby farms that is not properly treated can bring harmful bacteria or parasites.
- Feed that is not handled, processed, or stored correctly can also become a source of infection.

2. Spread within the Farm

- Shared tools or water systems can carry diseases from one tank or pond to another.
- Farms that stock multiple age groups without separation may see a faster spread of disease.

3. Exit from the Farm

- If not managed properly, infected animals or untreated waste can carry pathogens to other farms and the surrounding environment.

In Shrimp Farming - Why Biosecurity Matters??

Shrimp farms, especially those culturing *Litopenaeus vannamei*, have suffered devastating losses due to disease. The use of Specific Pathogen-Free (SPF) shrimp has become a critical tool. But SPF alone isn't enough.

Successful shrimp biosecurity combines:

- **Stock screening** before introduction
- **Quarantine protocols** (2–4 weeks) for new batches
- **Water disinfection**, often with UV or ozone
- **Effluent treatment** before discharge

According to studies, farms adopting SPF (Specific Pathogen Free) shrimp and strong biosecurity experienced lower mortality and higher yields, and importantly, were less likely to suffer total crop loss during regional outbreaks.

Building a Biosecure Aquaculture Farm

Fig.1: Elements of a strong farm-level biosecurity measures:

1. **Stock Health -** Use certified SPF (Specific Pathogen Free) or disease-free animals. Feed them a balanced diet and avoid stress factors.
2. **Sanitation -** Disinfect all tools, tanks, and equipment regularly. Provide footbaths and gloves for all farm staff.
3. **Movement Control -** Keep logs of all visitors and delivery vehicles. Use designated paths for feed, waste, and stock.
4. **Water Quality -** Filter and treat incoming water. Monitor key parameters like ammonia, oxygen, and pH.
5. **Vector Control -** Keep birds, rodents, and insects out with nets and barriers.
6. **Monitoring and Record keeping -** Use sedimentation ponds or constructed wetlands to treat outgoing water.

Advanced strategies where Technology meets Biosecurity

Modern biosecurity is evolving fast. New tools are helping farmers act earlier and smarter:

- **Sensors and IoT devices** monitor animal behavior and water quality in real time.
- **AI and data analytics** predict disease risks before symptoms appear.
- **Digital traceability systems** ensure transparency from hatchery to harvest.

Conclusion

In the face of mounting global demand for seafood – aquaculture must prioritize resilience and sustainability through comprehensive biosecurity frameworks. Disease outbreaks remain one of the most significant constraints to productivity and profitability in shrimp and broader aquaculture systems. As the sector intensifies and diversifies, the adoption of proactive biosecurity measures—ranging from SPF shrimp stocking and quarantine protocols to digital surveillance tools—has proven essential in mitigating pathogen risks. Transitioning from open water-exchange systems to more controlled and biosecure environments further reduces the likelihood of cross-contamination and enhances long-term viability. Ultimately, embedding biosecurity as a foundational component of aquaculture practice not only safeguards animal health and farmer livelihoods but also promotes food safety, reduces reliance on antibiotics, and supports compliance with international trade standards. Continued investment in innovation, training, and policy integration will be vital for ensuring the sustainable growth of aquaculture in an increasingly interconnected and disease-prone world.

References

Bera, K.K., Karmakar, S., Jana, P., Das, S., Purkait, S., Pal, S. and Haque, R., 2018. Biosecurity in aquaculture: an overview. Aqua International, 18(12), pp.42-46.

Subasinghe, R., Alday-Sanz, V., Bondad-Reantaso, M.G., Jie, H., Shinn, A.P. and Sorgeloos, P., 2023. Biosecurity: Reducing the burden of disease. Journal of the World Aquaculture Society, 54(2), pp.397-426.

Hine, M., Adams, S., Arthur, J.R., Bartley, D., Bondad-Reantaso, M.G., Chavez, C., Clausen, J.H., Dalsgaard, A., Flegel, T., Gudding, R. and Hallerman, E., 2010. Improving biosecurity: a necessity for aquaculture sustainability. In Global conference on aquaculture 2010.

Aly, S.M. and Fathi, M., 2024. Advancing aquaculture biosecurity: a scientometric analysis and future outlook for disease prevention and environmental sustainability. *Aquaculture International*, *32*(7), pp.8763-8789.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 05/VI/09/0625

MOLYBDENUM DEFICIENCY AND CORRECTIVE MEASURES

K. N. Tiwari

Ex. Director,
International Plant Nutrition Institute, 7A, Lakhanpur, Kanpur 208024
Corresponding Email: kashinathtiwari730@gmail.com

Abstract
Molybdenum is needed by plants in much less quantity compared with other micronutrients for chemical changes associated with nitrogen nutrition. The availability of molybdenum is pH dependent, and only Micronutrients are available above pH 7. Molybdenum increases nitrogen fixation, helps to assimilate nitrogen to synthesize amino acids, proteins, chlorophyll pigments, and enzymes, and enhances absorption of other nutrients from the soil and seed treatment with molybdenum is beneficial for all types of leguminous/ vegetables. Early application of Molybdenum through spraying helps in robust plant growth and development, induces more flowering, increases pollen fertility, and induces resistance against pest and diseases in Cereals, Horticultural, Plantation, and floriculture crops. The paper aims at highlighting the role of molybdenum in crop production, deficiency symptoms and corrective measures.

Introduction
Molybdenum (Mo) is one of the seven “micro” chemical elements required by plants. The other six are iron, copper, zinc, manganese, boron and nickel. These elements are termed ‘micro’ because plants need them in only very small amounts (in comparison with the ‘major’ elements nitrogen, phosphorus, potassium, sulphur, calcium and magnesium). But they are essential for normal growth. Of these seven micro elements, molybdenum is needed in smaller quantities than any of the others. As little as 50 grams of molybdenum per hectare will satisfy the needs of most crops. Molybdenum is often present in farmyard manure, in seeds or other planting material such as tubers and corms, and as impurities in some artificial fertilisers. The molybdenum supply from the seed appears to be significant only where the size of the seed is fairly large. For example, the molybdenum content of bean, pea and maize seed can be important, but that of tomato seed is probably of little significance.

Role of molybdenum in plant nutrition

- Molybdenum is a necessary component of more than 40 enzymes out of which two major enzymes in plants, nitrate reductase and nitrogenous, which are required for normal assimilation of nitrogen in plants.
- In non-leguminous plants helps in the assimilation of Nitrate to amino acids and proteins.
- Molybdenum is necessary for the process of symbiotic nitrogen fixation by Rhizobia bacteria in legume root modules.
- Molybdenum helps in nodule formation in legumes and increases the size of the nodules.
- In leguminous crops during symbiotic Nitrogen fixation, molybdenum co-factors the synthesis of enzymes which assists in the conversion of elemental Nitrogen into ammonium (NH_4^+) ions.
- Molybdenum helps to synthesis Ascorbic acid (Vitamin C), especially for citrus and lemon plants

- In coffee crops Molybdenum plays a significant role in the assimilation of Nitrogen resulting in new flush, better berry development, and increased yield.
- Molybdenum helps in the synthesis of sugars, Indole-3-acetic acid, and regulates the synthesis of Abscisic acid which controls plants against abiotic stress.
- Mo supply can strengthen plant metabolism at different growth stages through an improved enzymatic and non-enzymatic antioxidant defense system and enhance other pharmacological/medicinal properties of the plant.
- It is evident that Tomato Molybdenum sprays help to induce disease resistance against Verticillium wilt.

Molybdenum is needed by plants for chemical changes associated with nitrogen nutrition. In non-legumes (such as cauliflowers, tomatoes, lettuce, sunflowers and maize), molybdenum enables the plant to use the nitrates taken up from the soil. Where the plant has insufficient molybdenum, the nitrates accumulate in the leaves and the plant cannot use them to make proteins. The result is that the plant becomes stunted, with symptoms similar to those of nitrogen deficiency. At the same time, the edges of the leaves may become scorched by the accumulation of unused nitrates. In legumes such as clovers, lucerne, beans and peas, molybdenum serves two functions. The plant needs it to break down any nitrates taken up from the soil—in the same way as non-legumes use molybdenum. And it helps in the fixation of atmospheric nitrogen by the root nodule bacteria. Legumes need more molybdenum to fix nitrogen than to utilise nitrates.

In some crops, especially cauliflowers, there are very characteristic molybdenum deficiency symptoms. In others it is not always possible to diagnose with certainty whether a plant or a crop is suffering from a low supply of molybdenum. The best way to find out is to apply a solution of sodium molybdate or ammonium molybdate to the leaves of the plants or to the soil at their base, and see whether there is any response. This would be in the form of improved growth or development of a healthy leaf colour, compared with similar, untreated plants. Certain chemical tests can help diagnose molybdenum deficiency. In addition, the following can often help determine whether it is worthwhile making a trial application of molybdenum: • Occurrence of whiptail in cauliflowers in the same locality. Cauliflowers have a high molybdenum requirement. If they are growing well on an un-limed soil, and without any trace of whiptail disease, it is unlikely that other crops in that area would suffer from molybdenum deficiency.

Deficiency symptoms

- Molybdenum in acid soils tends to be unavailable to plants. This is why most molybdenum deficiencies occur on acid, rather than on neutral or alkaline soils. Molybdenum deficiency Occurs in acid soils (Low pH) sandy soil and leached soils. Using excess sulphate fertilizers can induce Molybdenum deficiency.
- Mo deficiency symptoms often resemble N deficiency symptoms with stunted growth, chlorosis poor development of nodules in legumes.
- In grapevines, molybdenum deficiency shows a bunch development disorder called Millerandage or 'hen and chicken' it is characterized by grapevine bunches showing the uneven size of the berries.
- Grapes vines showing Millerandage disorder also show symptoms of shortened zigzag-shaped inter nodes, pale-green leaves, increased cupped and flaccid leaves, and marginal leaf necrosis

- In cauliflower, the middle lamella of the cell wall is not formed completely when Molybdenum is deficient, with only the leaf rib formed, thereby giving a whiptail appearance.
- In maize, molybdenum deficiency shortens internodes, decreases leaf areas, and causes the development of chlorotic leaves
- Mo deficiency in citrus is commonly called "yellow spot." The deficiency occurs when trees are unable to absorb sufficient Mo from an acidic soil. Deficiency symptoms appear on the leaves as large, interveinal chlorotic spots.
- The inhibition of pollen formation with molybdenum deficiency may explain the lack of fruit formation in molybdenum-deficient watermelon.
- In coffee plants bright yellow spots develop near leaf margins and between leaf veins. These areas can turn necrotic. Leaves become distorted and narrow, rolling downwards. Older leaves are affected first.
- In molybdenum-deficient tomatoes, lower leaves appear mottled and eventually cup upward and develop marginal necrosis.

The main symptoms of molybdenum deficiency in non-legumes are stunting and failure of leaves to develop a healthy dark green colour. The leaves of affected plants show a pale green or yellowish green colour between the veins and along the edges. In advanced stages, the leaf tissue at the margins of the leaves dies. The older leaves are the more severely affected. In cauliflowers, the yellowing of the tissue on the outer leaves is followed by the death of the edges of the small heart leaves. When these develop, the absence of leaf tissue on their edges results in the formation of narrow, distorted leaves to which the name ‘whiptail’ has been applied. Affected leaves are usually slightly thickened and the leaf edges tend to curl upwards, especially in tomatoes. It has been mentioned that legumes such as peas and beans need molybdenum either for utilisation of nitrates (as do non-legumes), or for nitrogen fixation by root nodule bacteria. Where molybdenum is deficient, and adequate nitrogen is available from fertilisers applied to the soil, symptoms of molybdenum deficiency are similar to those seen in non-legumes, namely, interveinal and marginal leaf chlorosis followed by death of the tissue on the leaf margins. These symptoms are seen in a condition found in french beans in the Gosford district, to which the name ‘scald’ has been applied. In lucerne, clover and other pasture legumes, the main symptoms are associated with an inability to fix atmospheric nitrogen. This stunting and yellowing is identical with nitrogen deficiency and resembles legumes having no nodules and grown in poor soils.

Crop Specific Deficiency Symptoms

The highly acidic soils that are strongly weathered and leached and in soils where the element is in an unusable form Mo deficiency causes considerable yield losses. Mo deficiency problems are most common on acidic or sandy soils with low organic matters. As the nutrient is moderately translocated, its deficiency symptoms can appear across the whole plant and may easily be confused with other nutrient problems. Tissue analysis is recommended. Molybdenum deficiency in some crops is being described in following columns.

Wheat/Barley: Leaves show chlorosis and growth is stunted. Later on, the leaf tips get necrotic. Molybdenum deficiency N deficiency produces similar effects (**Photo 1**).

Photo 1. Molybdenum deficiency in mustard

Mustard: Oilseed mustard is rather sensitive to molybdenum deficiency. The molybdenum deficiency symptom is characterised by pale grey-green discoloration of the foliage (**Photo 2**).

Photo Molybdenum deficiency in mustard

Yellows (Molybdenum deficiency) in cucurbits

Yellows is the result of a molybdenum deficiency in cucurbit plants. Crown leaves become bright yellow and margins become necrotic. Leaves are stunted and mis-sharpened. Symptoms move out the runners until the entire plant is affected. Fruit set is eliminated and plants may be killed Molybden (**Photo 3**). um is generally available in high enough quantity for all plant growth. However, under acid soil conditions molybdenum is difficult for melons of some cultivars to absorb. A single application of sodium molybdate at 200 ppm will result in a complete recovery of affected plants in 2 to 3 days.

Photo 3 Molybdenum deficiency in cucurbits

Cauliflower: The molybdenum deficiency in cauliflower is diagnosed as distorted leaves with reduced leaf area and chlorotic leaf margins. "Whiptail" formation. Symptoms begin at the younger leaves (**Photo 4 and 5**). Molybdenum deficiency is made worse by acid soils, low pH and low levels of soil organic matter.

Photo 4. Molybdenum deficiency at early stage of cauliflower

Photo 5. Molybdenum deficiency “Whip tail” in cauliflower

Cabbage: Mo deficient plants show a faint yellow-green chlorosis. Leaves of young plants are relatively small and bent down. Their edges are more serrated than usual (**Photo 6**).

Photo 6. Molybdenum deficiency in cabbage (right)

Sweet Potato: Although molybdenum deficiency has not been described in field-grown sweet potato, symptoms resembling those of N deficiency are expected. Such symptoms would include a general pale green colour, stunted growth with small leaf size, and possible reddening of veins on the young leaves. In plants grown in solution culture, the following symptoms were associated with a mild growth reduction from molybdenum deficiency. In some cultivars older leaves developed silvery patches over interveinal tissue, as a result of the upper epidermis separating from the underlying tissue. Eventually these patches became necrotic, but necrosis did not spread readily from the isolated interveinal patches. In some cultivar, the young to recently mature leaves displayed a mild interveinal chlorosis, with some interveinal areas becoming necrotic. In some other cultivar, chlorosis was more uniform, and the recently mature leaves commonly developed a marginal scorch, especially at the tips of lobes (**Photo 7**).

Photo 7. Molybdenum deficiency in sweet potato

Tomato: The leaves show some mottled spotting along with some interveinal chlorosis. An early symptom for molybdenum deficiency is a general overall chlorosis, similar to the symptom for nitrogen deficiency but generally without the reddish coloration on the undersides of the leaves (**Photo 8**).

Photo 8. Molybdenum deficiency in tomato

Cucumber: Molybdenum deficiency in cucumbers can cause various issues, including yellowing of leaves, stunted growth, and poor fruit development. It's often identified by interveinal chlorosis (yellowing between veins while veins remain green), particularly in older leaves, and can lead to leaf curling and necrosis. Molybdenum is crucial for nitrogen uptake and utilization, so deficiency can manifest as nitrogen-related symptoms (**Photo 9**).

Photo 9. Molybdenum deficiency in cucumber

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Poinsettias: Molybdenum deficiency in poinsettias manifests as yellowing (chlorosis) along the leaf margins, especially in the middle and upper leaves. This chlorosis can progress to marginal necrosis (leaf edge burn) and leaf cupping or rolling (**Photo 10**). The deficiency is more likely to occur in poinsettias grown in soilless media with low pH (below 5.5) or when the molybdenum supply is insufficient.

Photo 10. Classic molybdenum deficiency in poinsettia is shown as a thin, leaf margin chlorosis

Soyabean: Mo deficiency symptoms are similar to N deficiency: Leaves are pale green to yellow and twisted. At progressing deficiency, the leaf margins, midribs and interveinal areas become necrotic (Photo 11).

Photo 11 Molybdenum deficiency in soybean

Factors influencing molybdenum availability

Soil acidity: As mentioned earlier, molybdenum deficiency is more likely on acid soils having a pH of 5.5 or less.

- *Use of farmyard manure.* Where large amounts of farmyard manure have been used, molybdenum deficiency is less likely.
- *Patchy distribution of affected plants.* Patchy distribution is characteristic of molybdenum deficiency. The whole crop may be affected, but it is much more usual to find patches of affected plants in an otherwise healthy crop, or vice versa.

Control measures

In most soils, molybdenum present in an unavailable form will be released by applying lime or dolomite. The effect of liming on molybdenum availability is slow and it may take several months to correct the deficiency. The amounts of lime or dolomite needed may range from 2 to 8 tonnes per hectare, depending on initial pH of the soil and whether it is sandy or heavy textured. Unless lime is likely to be beneficial for other reasons, it is quicker and cheaper to apply a molybdenum compound to the soil or to the crop. Where one of the molybdenum compounds is used, the quantities recommended vary from 75 g to 1 kg/ ha depending on the crop and the molybdenum material. Molybdenum can be applied in the following ways:

- mixed with fertiliser; or in solution,
- to seedlings in the seedbed before transplanting;
- the leaves of plants in the field or the soil at the base of plants in the field.

Crop recommendations

Clovers and lucerne: Molybdenum trioxide (or equivalent amounts of sodium molybdate or ammonium molybdate): 75 g/ ha mixed with superphosphate.

Vegetable crops: (a) Mixed with fertiliser. Ammonium molybdate or sodium molybdate, 1 kg/ha (b) Seedbed application to crops such as cauliflower, broccoli, cabbage and tomato. Ammonium molybdate or sodium molybdate, 40 g dissolved in 50 L water and watered on to each 10 m^2 of seedbed about one to two weeks before transplanting. (Following such seedbed applications, cauliflower seedlings often develop a distinct blue colour in the stems and leaves. This blue colour gradually disappears when they are transplanted.)

Characteristics and occurrence

Molybdenum (Mo) is unusual among the micronutrients in becoming less available to plants at low soil pH. Therefore, molybdenum deficiency is usually associated with acid soils (pH <5.5), particularly those which are geologically old and highly leached. As soils low in molybdenum are often also low in phosphorus and sulphur, molybdenum may not be apparent unless phosphorus and sulphur deficiencies have been corrected by fertilisation.

Molybdenum is required by plants in very small quantities. Its main (and possibly only) function in non-leguminous plants is as a component of the enzyme nitrate reductase, which is essential for the metabolism of nitrate, the main form of plant-available nitrogen in most soils. Therefore, molybdenum deficient plants may appear as if they are deficient in nitrogen, having general chlorosis and stunted growth. Symptoms unlike those of nitrogen deficiency may occur as a result of nitrate accumulation to toxic levels in the tissue.

Diagnostic Soil and Plant Tissue Tests

From solution culture studies, the critical concentration for deficiency of molybdenum was found to be approximately 0.2 mg Mo/kg in the 7th to 9th youngest leaf blades. Equivalent leaves from healthy plants contained 0.5 - 7 mg Mo/kg.

Molybdenum Compounds for Correcting Deficiency

Molybdenum compounds used for crops include molybdenum trioxide, sodium molybdate and ammonium molybdate. Choice of the material to be used depends on whether it is to be applied with fertilizer or as a solution Molybdenum trioxide is only partially soluble in water. It is the form usually used in molybdenized superphosphate but is not suitable for making up sprays to treat a growing crop. Molybdenum trioxide (also called molybdic oxide) contains 66 per cent molybdenum. Ammonium molybdate contains 54 per cent molybdenum. Though it is soluble in water, it is frequently sold in large lumps which dissolve slowly in cold water. It is better either to use hot water to dissolve the lumps or to crush them to a fine powder before adding to the water. Sodium molybdate is usually sold in a form containing 39 per cent molybdenum. It is sold as fine crystals which dissolve readily in cold water and this material is undoubtedly the most convenient for the preparation of solutions to be used for spraying.

Management of Mo Deficiency

- Molybdenum deficiency is relatively easily corrected, either by the application of small quantities of molybdenum to the soil, or by raising the soil pH.
- Application of sodium molybdate or ammonium molybdate at rates of 0.2-0.3 kg Mo/ha should be sufficient to correct the disorder in most situations, and may be effective for several years. Sodium molybdate may also be applied as a foliar spray. A solution of 50 g sodium molybdate/100 L water has proven successful with other crops such as sunflower.
- Liming to raise the soil pH above 5.5 is usually effective in alleviating molybdenum deficiency, and may improve conditions for crop growth in other ways also, such as through improved availability of phosphorus and alleviation of manganese or aluminium toxicity.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/10/0625

CAPTIVE BREEDING OF STRIPED CATFISH (*Pangasianodon hypophthalmus*) USING DIFFERENT INDUCING AGENTS

S. Selvaraj*, T.L.S. Samuel Moses, P. Ruby, V. Ezhilarasi, A. Jackqulin Wino and R. Jeya Shakila

Tamil Nadu Dr.J.Jayalalithaa Fisheries University,
Dr.M.G.R. Fisheries College and Research Institute,
Department of Aquaculture, Ponneri, Thiruvallur, Tamil Nadu
*Corresponding Email: selvaraj@tnfu.ac.in .

Introduction

Asian striped catfish, *Pangasianodon hypophthalmus* is considered as a superior aquaculture species for tropical regions, and is the important economic freshwater species in southeast Asia (Pal, 2010; McGee, 2014,). It is a large freshwater fish, also known in the other names such as iridescent shark, pangasius catfish, striped catfish, sutchi catfish, freshwater catfish (Roberts and Vidthayanon, 1991; Griffith *et al*., 2010). Culture of this species is gaining importance in India (Lakra and Singh, 2010; Singh and Lakra, 2012 Kumar *et al*., 2013), Bangladesh (Rahman *et al*., 2006; Ahmed and Hasan, 2007; Ahmed *et al*., 2013), Indonesia (Griffith *et al*., 2010) and Vietnam (Phan *et al.,* 2009; Bui *et al*., 2010). In India, its culture was initially carried out in Andhra Pradesh and West Bengal; however, the Government of India permitted aquaculture of *P. hypophthalmus* since 2010-2011. The fish is cultivated both under monoculture as well as polyculture with Indian major carps. In India, culture production of *P. hypothalamus* is 15-20 ton/ha/yr which is higher than carp production (8-10 ton/ha/yr) in the same area (Singh and Lakra, 2012). The species is cultured in different aquaculture systems including traditional earthern ponds, cages, recirculatory aquaculture system and biofloc based culture systems.

Size at first maturity

Males and females are easily distinguishable; females are identified by their big, soft and swollen and reddish pink distended belly and males by their reddish genital opening and oozing of milt, when the abdomen is pressed. Breeding starts from April and continues until mid September (Lakra and Singh, 2010). Females of *P. hypophthalmus* attains maturity at an age of 3 years; however, under captive conditions it has been shown to mature at an age of 2 years (Lakra and Singh, 2010; Singh and Lakra, 2012). The male fish attain maturity in 2 years, and under captivity, mature earlier than 2 years. Reports indicate earlier maturity in pond reared striped catfish stocks. In Indonesia, pond reared *P. hypothalamus* were shown to attain maturity in 10 months of age for males (472±78 g) and 19 months of age for females (2249±279 g) (Kristanto *et al*., 2005). The water temperature of the ponds during the culture period varied between 28 and 31°C. Fecundity of the fish found to be 49,000-372000 eggs/kg of fish. The mature females possessing egg diameter more than 1 mm can be induced to spawn using hormonal treatments (Kristano *et al*., 2005). It is indicated that *P. hypothalamus* require higher water temperature to initiate sexual maturity.

Feeding management

Different feeds have been indicated for developing the broodstock for induced breeding in captivity. Shabuj *et al*. (2016) used formulated feeds two days and commercially available market feeds five days per week in a broodstock pond. The formulated feed consisted of following feed ingredients: fish meal (10%), rice polish (30%), maize meal (20%), soyabean meal (15%), mustard oil cake (20%), Ata (4%) and vitamin (1%), and the broodstock were fed at 2-2.5% body weight. Datta *et al*. (2018) recommended use of formulated floating feed prepared (28.0% crude protein and 4.5% crude fat on dry weight basis) using extruder and containing following feed ingredients: rice bran (30%), de-oiled ground nut (30%), de-oiled soybean (25%), fish meal (13%) and commercially available multivitamin and multi-mineral mixture (2%). The broodstock were fed at 2% of body weight in two meals equally distributed at 9 am and 5 pm. Pamungkas *et al*. (2019) used commercially available catfish feed (38% crude protein) and fed the broodstock at 3% of the body weight. The water temperature of the broodstock pond is maintained between 26 and 30°C.

Induced breeding using different inducing agents

Crude Pituitary extract

The pituitary extract prepared from pituitary glands of Indian major carps and Chinese carps are used for induced breeding of *P. hypothalamus* (Table 1 and Figure 1). Shabuj *et al*. (2016) collected eggs and sperm after 6 hours of second dose administration, using stripping method and performed dry fertilization. The authors recorded higher fertilization rate (87%), hatching rate (82%), and survival rate (80%) in fish administered with pituitary gland extract at a dose of 12 mg/kg. However, Datta *et al*. (2018) collected gametes after 14 hours of second dose pituitary extract injection. The authors achieved lower fertilization and hatching rate of 76.5% and 58.2%, respectively compared to the results of Shabuj *et al*. (2016). These observations clearly suggest that timing of gamete collection is important in getting higher percentage of fertilization and hatching rate in striped catfish seed production. Also, Shabuj *et al*. (2016) administered the pituitary extract at 1mg/kg to males as single dose at the time of first injection to females. In contrast, Datta *et al*. (2018) injected pituitary extract at 2.5-3 mg/kg as single dose at the time of second injection to females.

In Asian striped catfish, gametes are collected using stripping, and fertilization performed for incubation and hatching in the jars or other suitable hatchery models. In brief, the eggs and sperms are collected from the ovulated females and males by gentle pressing of the abdomen of fishes. Eggs are collected in the suitable container like plastic cups and then mixed with milt using soft bird feather. Later, mixing is performed for 45-60 seconds using soft feather, and freshwater is added into fertilized eggs. The swollen eggs are immediately transferred into hatching jars (Figure 2).

Table 1. Pituitary gland extract and their doses used in induced breeding

Inducing agent	Size of the broodstock (total length/ body weight)	Hormone dose	Reference
Carp pituitary gland extract	2.4-3.5 kg	Females: First dose: 2.5-3 mg/kg Second dose: 10-11 mg/kg Males: 2.5-3 mg/kg as single dose at the time of second injection to females	Chand *et al*., 2011

Inducing agent	Size of the broodstock (total length/ body weight)	Hormone dose	Reference
Pituitary gland extract	Female, 4.47±0.55 kg Male, 3.65±0.44 kg	Females: First dose: 2 mg/kg Second dose: 12 mg/kg Males: 1mg/kg as single dose at the time of first injection to females	Shabuj *et al*., 2016
Carp pituitary gland extract	Juvenile fish raised to adults in the earthern pond	Females: First dose: 2.5-3 mg/kg Second dose: 10-12 mg/kg Males: 2.5-3 mg/kg as single dose at the time of second injection to females	Datta *et al*., 2018

Figure 1. Use of carp pituitary glands and their extract in induced breeding

Figure 2. Collection of gametes through stripping, and mixing for artificial insemination and incubation

Gonadotropins

Several studies have indicated the use of natural and synthetic gonadotorpins in the induced breeding of Asian striped catfish (Table 2 and Figure 3). Administration of human chorionic gonadotropin (HCG) alone induces release of gametes (Cacot, 1998; Baidyo and Senoo, 2002; Bui *et al*., 2010). Multiple doses of HCG are required for induced maturation and release of gametes for artificial insemination. Unlike, other pangasiid catfish, females of *P. hypophthalmus* do not require a preliminary HCG treatment, as they have naturally large oocyte sensitive to the multiple hormone treatment (Cacot, 1998). Females undergoing different stages of oogenesis are identified by observing the oocytes under microscope in clearing solution, collected using cannalution tube (Baidyo and Senoo, 2002). The above authors have found that the mean diameter of the newly ovulated eggs ranged from 1.06 to 1.12 mm. Stripping was performed between 7 h 30 min and 14 h 30 min after the second injection, and the number of eggs ranged between 1423 to 2052 eggs/g of the ovary. This study administered two intraperitoneal HCG injections at the basal section of the pectoral fin, and the time interval between first and second dose was 14 h, and achieved fertilization and hatching rate of 80.6±5.0% and 56.8±12.4%, respectively. Bui *et al*. (2010) have achieved higher fertilization and hatching rate of 86±2.2% and 88±1.2%, respectively by administering multiple HCG injections, suggesting the importance of HCG in maintaining elevation of circulating sex steroids, including estradiol-17β and 17α-20β-dihydoxy-pregnone-3-one.

Studies have also indicated the use of pregnant mare serum gonadotropin (PMSG) alone or in combination with HCG for inducing maturation and release of gametes (Tahapari *et al*., 2014; Pamungkas *et al*., 2019; Samara *et al*., 2019). Tahapari *et al*. (2014) have indicated the importance of circulating estrogen level in the blood, with gonad maturation generally occurring 2 to 4 weeks after estradiol-17β peak. The authors have observed higher fecundity value (4,88,433±1,42,228 eggs) in fish administered with combination of PMSG and HCG. In fish administered with PMSG alone, higher reproductive performance was demonstrated, including higher concentration of estradiol and vitellogenin in blood plasma during the vitellogenesis (Pamungkas *et al*., 2019). The authors have achieved higher fertilization (96.57±1.28%) and hatching rate (93.81±2.70%). In another study, broodstock treated with 10 IU PMSG and 5 IU HCG/kg of body weight was able to reach maturity, and spawned with the larval survival rate on the fourth day at 84.81%. Interestingly, this study administered vitamin mix along with the hormones (Samara *et al*., 2019).

Table 2. Gonadotropins and their doses used in induced breeding

Inducing agent	Size of the broodstock	Hormone dose	Reference
Human chorionic gonadotropin (HCG)	Females, 7.3±1.6 kg	Females: Single dose, 2530 IU/kg; Double dose, 2530 and 2520 IU/kg; Triple doses, 490, 1000, and 1500 IU/kg Males: Single dose, 2000 IU/kg	Cacot, 1998
HCG	Females, 49-66 cm; 1.3-2.9 kg	First dose: 500 IU/kg Second dose: 1500 IU/kg	Baidyo and Senoo, 2002
HCG	Male, 0.5-8 kg; Female, 0.5-12 kg	Fmeales: Five doses, 500, 500, 500, 1500 and 3000 IU/kg; injected at 0, 23, 46, 56 and 66 hrs	Bui *et al*., 2010

Inducing agent	Size of the broodstock	Hormone dose	Reference
Pregnant mare serum gonadotropin (PMSG) and HCG	Females, 2.39± 353.94 kg	Combination of PMSG, 20 IU/kg and HCG, 10 IU/kg	Tahapari *et al*., 2014
PMSG	Females, 2.5-4 kg; Males, 2-3 kg	20 IU/kg	Pamungkas *et al*., 2019
PMSG, HCG and vitamin mix	-	10 IU PMSG, 5 IU HCG/kg and vitamin mix 300 mg/kg	Samara *et al*., 2019

Figure 3. Use of HCG and PMSG in induced breeding

GnRH analogues

GnRH analogues, Ovaprim, Ovatide, Gonopro-FH, WOVA-FH, Ovulin and Buserlin are used for induced breeding of striped catfish (Table 3 and Figure 4). Manosroi *et al*. (2004) found that the fish administered with GnRHa in combination with dopamine antagonist, domperidone induced significant changes in circulating sex steroids, testosterone and estradiol-17β levels, and their levels correlated with an increase in gonadosomatic index (GSI) values. Using Gonopro-FH and WOVA-FH, 60-80% fertilization was achieved by Samuel Moses *et al*. (2016). However, the authors obtained the egg development upto late C-cell embryo stage only. The fish administered with Ovulin (0.5 ml/kg) was found effective to induce spawning after 8-14 h of latency period, and this method resulted in the mean fertility and hatching rates of 90.1±5.9% and 73.2±11.6%, respectively (Sah *et al*., 2018). In this case, the authors have maintained the fish for two years in captivity and the fish responded to Ovulin administration. Two doses of Ovaprim at 0.5ml/kg were administered to the females in an interval of six hours, and the males was given one dose of 0.5ml/kg body weight at the time of the second injection given to the female. Ovulation was observed 5-6 hours, and the study achieved fertilization rate of 85-95% (Abeysinghe *et al*., 2019).

Table 3. GnRH analogues and their doses used in induced breeding

Inducing agent	Size of the broodstock	Hormone dose	Reference
GnRHa and domperidone	Average body weight, 900 g	GnRHa: 300 µg/kg Domperidone: 20 mg/kg	Manosroi *et al*., 2004
Ovaprim and Ovatide	2.4-3.5 kg	Ovaprim Females: 0.4-0.5 ml/kg Males: 0.3-0.4 ml/kg	Chand *et al*., 2011

Inducing agent	Size of the broodstock	Hormone dose	Reference
		Ovatide Females: 0.5-0.6 ml/kg Males: 0.2-0.3 ml/kg	
Gonopro FH and WOVA-FH	Females: 2.3-3.5 kg Males: 1.48-2.6 kg	Females: 0.3-0.5 ml/kg; Males:0.3-0.35 ml/kg	Samuel Moses *et al.*, 2016
Ovulin	2.5-3 kg	Female: 0.5 ml/kg Male: 0.25 ml/kg	Sah *et al.*, 2018
Ovaprim	Average length 35 cm; Females: 2.8-3.3 kg	Females: 0.5ml/kg twice Males: 0.5ml/ kg once	Abeysinghe *et al.*, 2019

Figure 4. Use of GnRH analogues in induced breeding

Conclusion

Different inducing agents have been administered to striped catfish to obtain the gametes for artificial insemination. The percentage of fertilization and hatching vary based on the type of inducing agent, and the timing of gamete collection. Studies clearly indicate that the nutritional and environmental condition influences the efficiency of different inducing agents. It is well demonstrated that GnRH analogues are widely used for inducing final oocyte maturation, ovulation and spermiation in captive maintained teleost fish. Unlike other perciform fish expressing seabream GnRH as GnRH I form, pangasiid catfish including *P. hypothalamus* are likely to express catfish GnRH as GnRH I form as reported in African catfish. Hence, it would be interesting to investigate the potency of GnRH analogues of catfish GnRH forms in inducing the gamete maturation.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/11/0625

AI AND MACHINE LEARNING APPLICATIONS IN PEST FORECASTING: AN INDIAN PERSPECTIVE

Shanmugapriya V[1]* and S. Karthikeyan[2]

[1]Department of Crop Protection, Kumaraguru Institute of Agriculture, Erode – 638 315.
[2]Deputy Manager (Quality Control), Tamil Nadu Civil Supplies & Corporation,
Coimbatore – 641659.
*Corresponding Email: shanmugapriya_aen@kia.ac.in

Abstract
India, being an agrarian economy, faces significant crop losses due to insect pest outbreaks. Traditional forecasting models based on historical and climatic data often fail to accommodate the complex, non-linear interactions that affect pest populations. With recent advancements in Artificial Intelligence (AI) and Machine Learning (ML), predictive modelling has seen a paradigm shift in pest management strategies. This article presents a comprehensive overview of AI/ML applications in pest forecasting, focusing on Indian agricultural systems. It covers recent developments, case studies, challenges, and future prospects, emphasizing the need for integrated digital agriculture approaches.

Keywords: Artificial Intelligence, Machine Learning, Pest Forecasting, Indian Agriculture, Precision Entomology

Introduction

India's agricultural productivity is intricately linked with timely and effective pest management. Annual losses due to insect pests are estimated to be between 15-25%, depending on the crop and region. Traditionally, pest forecasting in India has relied on empirical models, expert-based systems, and agrometeorological indices. However, the dynamic nature of pest outbreaks, driven by climate change and cropping pattern shifts, demands more robust and adaptive forecasting tools. AI and ML offer promising alternatives by enabling models that learn from large-scale, multi-dimensional datasets to detect patterns and predict outcomes.

Overview of AI and ML Techniques

AI is a broader domain that includes machine learning, deep learning, and neural networks. ML algorithms such as Decision Trees, Random Forest, Support Vector Machines (SVM), Artificial Neural Networks (ANN), and newer methods like Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN) have found applications in entomological research and pest prediction.

Applications in Indian Pest Forecasting

Several initiatives and research efforts have been made in India to harness AI/ML for pest forecasting:

Pest Surveillance Using ANN and SVM: Research at ICAR institutions has demonstrated the use of SVM and ANN models for predicting *Helicoverpa armigera* infestation in chickpea and cotton based on weather parameters and cropping data.

Mobile Apps and Decision Support Systems: Platforms like e-SAP (electronic Solutions Against Agricultural Pests) and mKRISHI integrate machine learning algorithms with real-time pest observation data, offering actionable advisories to farmers.

Remote Sensing and Satellite Data Integration: AI models coupled with remote sensing have been used for locust swarm predictions, with collaborative support from ISRO and IMD.

Case Studies

Locust Forecasting Model (2020): A hybrid model integrating deep learning with meteorological data accurately predicted locust movements across Rajasthan, Gujarat, and Madhya Pradesh.

Cotton Pink Bollworm Prediction: In Maharashtra, time-series modeling using RNN and LSTM (Long Short-Term Memory) networks helped identify infestation peaks, aiding in timely interventions.

Challenges and Limitations

Data Availability and Quality: Reliable, geo-tagged pest incidence data is often lacking or inconsistent.

Lack of Interdisciplinary Collaboration: Effective AI implementation requires seamless collaboration between entomologists, data scientists, and software engineers.

Farmer Awareness and Adoption: Adoption is low due to limited digital literacy and infrastructure.

Future Prospects

Integration with IoT Devices: Sensor-based monitoring combined with ML can enable real-time forecasting.

Open Data Platforms: National initiatives to develop standardized pest data repositories will enhance model accuracy.

Localized Model Customization: Region-specific models accounting for microclimatic variations and cropping systems are crucial.

Conclusion

AI and ML hold immense potential in revolutionizing pest forecasting in Indian agriculture. While some progress has been made, scalable implementation depends on multi-stakeholder collaboration, investment in digital infrastructure, and capacity building among end-users. With appropriate policy support, AI-driven pest forecasting can significantly reduce crop losses and promote sustainable pest management.

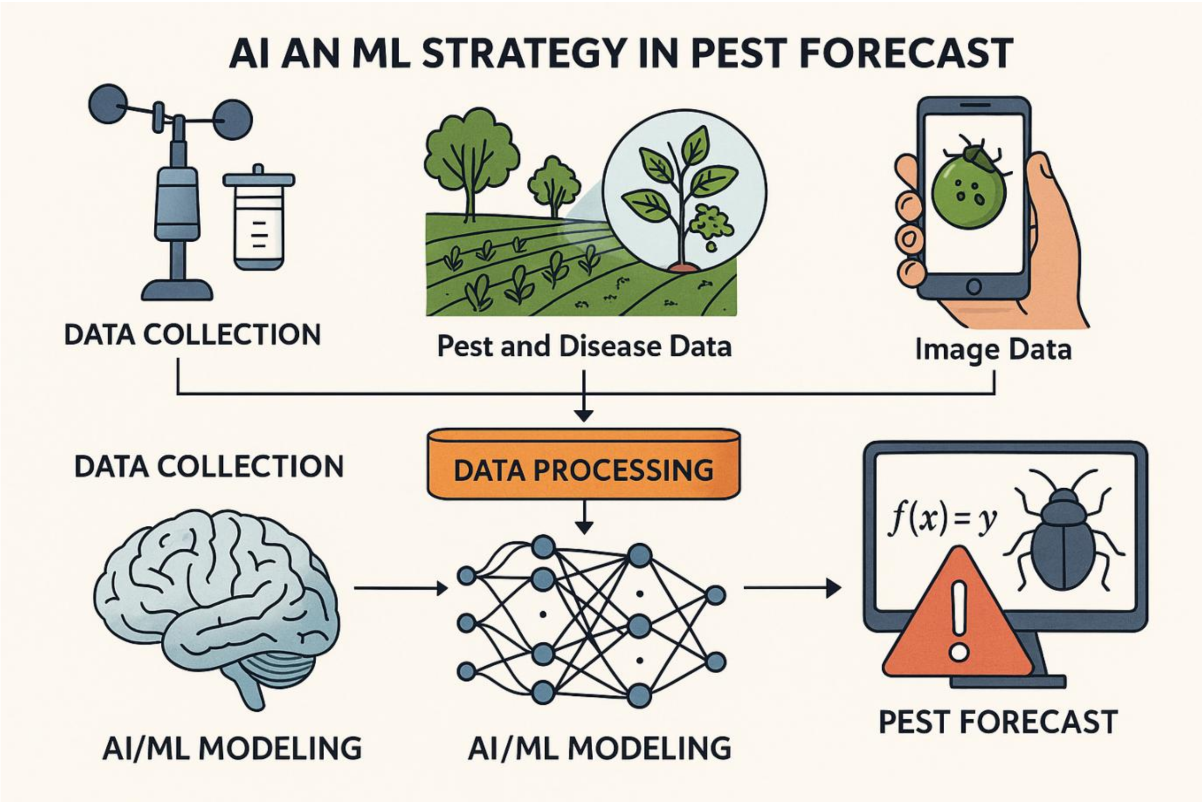
References

Government of India (2020). Locust Forecasting and Early Warning System. Ministry of Agriculture & Farmers Welfare, New Delhi.

ICAR-NCIPM. (2022). Annual Report 2021-22. National Centre for Integrated Pest Management, New Delhi.

Patel, H. R., & Rathod, P. H. (2021). Forecasting pest infestation using LSTM networks: A study on cotton in Maharashtra. Computers and Electronics in Agriculture, 187, 106285.

Sannakki, S. S., Rajpurohit, V. S., & Ramesh, H. (2023). Machine Learning Techniques for Pest Detection and Forecasting in Agriculture: A Review. Journal of the Indian Society of Agricultural Statistics, 77(1), 15-24.


AI AN ML STRATEGY IN PEST FORECAST
DATA COLLECTION
Pest and Disease Data
Image Data
DATA COLLECTION
DATA PROCESSING
f(x) = y
AI/ML MODELING
AI/ML MODELING
PEST FORECAST

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/12/0625

CHAMOMILE : A STAR OF MEDICINAL PLANTS

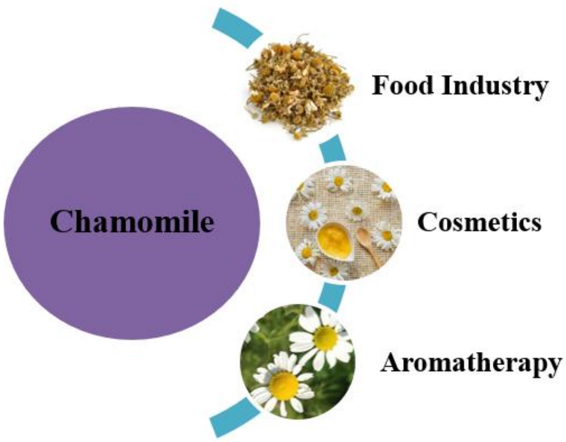
Anamika Sajwan[1], Harshita Bora[1], Mukesh Kumar[2*] and V K Rao[3]

[1] Ph.D. Research Scholar, Department of Horticulture,
G.B. Pant University of Agriculture and Technology, Pantnagar,
U.S. Nagar, Uttarakhand
[2]Assistant Professor, Dept. of Agriculture, Tula's Institute,
Dhoolkot, Dehradun, Uttarakhand
[3] Professor, Department of Horticulture,
G.B. Pant University of Agriculture and Technology, Pantnagar,
U.S. Nagar, Uttarakhand
*Corresponding Email: mukesh.gpswr@gmail.com

Introduction

Matricaria chamomilla L. called German chamomile, is one of the important medicinal herbs indigenous to Southern and Eastern Europe. It consist of two Greek words Chemos and Melos, that mean "ground apple" due to their apple-like scent, are the origins of the word "chamomile." Chamomile was well-known in ancient Egypt, Rome, and Greece and has been employed for thousands of years in herbal remedies. Its nutritional, multitherapeutic, and cosmetic qualities have earned it the title of "star of medicinal plants." In Hindi, it is known as Babuna. In the world, it is commercially cultivated in Brazil, Russia, Yugoslavia, France, Germany, and Hungary. The primary producer of plant biomass is Hungary. It was brought to India during the Mughal era approximately three centuries ago, and today it is grown in Jammu and Kashmir, Uttar Pradesh, Punjab, and Maharashtra. The worldwide market of chamomile oil has been increasing steadily. In addition to being a significant food, cosmetic, and pharmaceutical additive, it is the fifth most popular herb in the world.

Around the world, it is marketed as either flower heads or as blue oil, which is the commercial trade name for chamomile oil. In order to produce its essential oil, the plant has been introduced to some Asian countries and is now widely grown in Europe. It has antibacterial and fungicidal properties and is also used as a mild sedative and for digestion. The oil has many applications in the food industry, cosmetics, aromatherapy, and perfumery in addition to pharmaceuticals. In addition, chamomile is grown as an ornamental flower crop.



Botanical Description

Chamomile is native to temperate regions of Asia and Europe. This diploid species (2n=18) belongs to the Asteraceae family. The plant produces double feathery leaves and branched stems, reaching a height of 10 to 80 cm. The plant has a capitulum inflorescence, which is made up of 10–25 white ray flowers encircling a central cone of bright golden yellow tubular florets. Bees and butterflies are drawn to the flowers, which have a potent, fragrant scent reminiscent of apples. A yellowish-brown achene is the fruit.

Cultivation

German Chamomile can be grown in any type of soil, but it is best to avoid rich, heavy, and damp soil. Since, the crop has a high tolerance to soil alkalinity, it can be grown well on poor soils (loamy sand) with pH ranging from 9 and 9.2. Light (sunshine hours) and temperature have a bigger impact on the content of essential oils. It is also capable of withstanding cold temperatures between 2°C and 20°C. Commercially, it is propagated through seeds. There are two ways to grow the crop first one is direct seeding and another one is transplanting method. Since, direct seeding yields poor germination. Therefore, transplanting method is commonly used for its successful cultivation. The seed size of the crop is extremely small. Therefore, care should be taken during the process of sowing. Generally, 0.3 to 0.5 kg of seed is sown in 200–250 m^2 nursery for one hectare of land. Although, transplanting is a labour-intensive process and rate of seedling mortality also very less. The optimum temperature range for seed germination is 10°C to 20°C. In North India, September is the best time to raise seedlings in nursery. Seeds germination starts after 4-5 days of sowing under favourable conditions and seedlings are ready for transplanting in 4-5 weeks. These are some important cultivars which includes CIM – Sammohak, Prasant, CIM- Ujjwala and Vallary etc. released by CIMAP, Lucknow.

The growth of crop is slow till mid-January and picks up gradually until early February. Bud formation occurs in March, and irrigation during the bloom period helps to increase flower yield. The most labour-intensive part of growing chamomile is harvesting, which contributes significantly to production costs. The peak flowering season lasts from March to April and lasts for three to six weeks. The flowers that are nearly fully bloomed are of the highest quality. Flowers are produced in flushes, with 4-5 flushes being obtained. A maximum of 7637 kg of fresh flowers can be grown in normal soils, with an average of 3500-4000 kg/ha.

Therapeutic properties

The chamomile is listed in the pharmacopoeias of 26 nations. It is a component of numerous Homeopathic, Unani, and traditional medicine preparations. It is regarded as a "cure all" in Europe and is called "alleszutraut" in German, which means "it can do anything." The main components of chamomile are thought to be sesquiterpenes, coumarins, flavonoids, and polyacetylenes. Commercial chamomile cultivation is practiced in many countries for its blue oil, herbal tea, pharmacological, and cosmetic applications. In *M. chamomilla* flowers the blue essential oil ranges from 0.2 to 1.9% and has variety of applications. The presence of terpenoids and flavonoids is indicated chemically by the quality of blue oil. Its flower heads and essential oils have sedative, antibacterial, antiseptic, anti-inflammatory, and antispasmodic properties. It's interesting to note that Germany named it "the medicinal plant of the year" in 1987. Poland, Hungary, Germany, Argentina, and Czechoslovakia—the world's top suppliers of chamomile, have recently launched extensive plant improvement initiatives to create plants with high concentrations of essential oils and a specific chemical makeup. A tincture made from chamomile flowers is used to treat children's diarrhoea, and an extract is used in pharmaceutical formulations to treat toothaches, earaches, and neuralgia. Additionally, chamomile's dry flowers are highly sought after for use in baby massage oil, to encourage the flow of secretions from the stomach, and to treat colds and coughs. The powdered medication can be applied externally to slow-healing wounds, infections, skin eruptions, including boils and shingles, haemorrhoids, and inflammation of the mouth, eyes, and throat.

Conclusion

Chamomile is one of the most important and widely used medicinal plants in folk and traditional medicine throughout the World. Cropping duration of Camomile is 120- 180 days crop and highly tolerant to soil alkaline condition. The demand for chamomile oil and flower is increasing steadily on a global scale because of its established nutritional, cosmetic, and multitherapeutic benefits. Therefore, more emphasis would be given on the cultivation of crops in future.

References

Dai, Y. L., Li, Y., Wang, Q., Niu, F. J., Li, K. W., Wang, Y. Y., Gao, L. N. (2023). Chamomile: a review of its traditional uses, chemical constituents, pharmacological activities and quality control studies. Molecules, 28(1), 133.

Sah, A., Naseef, P. P., Kuruniyan, M. S., Jain, G. K., Zakir, F., Aggarwal, G. (2022). A comprehensive study of therapeutic applications of chamomile. Pharmaceuticals, 15(10), 1284.

Singh, O., Khanam, Z., Misra, N., Srivastava, M. K. (2011). Chamomile (*Matricaria chamomilla* L.): An overview. Pharmacognosy reviews, 5(9), 82.

Srivastava, J. K., Shankar, E., Gupta, S. (2010). Chamomile: A herbal medicine of the past with a bright future. Molecular medicine reports, 3(6), 895-901.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 05/VI/13/0625

MANAGEMENT OF SOIL COMPACTION IN AGRICULTURAL FIELDS

Abishek[1]*, Sunil Shirwal[2], Maheshwari[1] and Satish[1]

[1]PhD Research Scholar, Department of Farm Machinery & Power Engineering,
University of Agricultural Sciences, Raichur, Karnataka 585104
[2]Associate Professor, Department of Farm Machinery & Power Engineering,
University of Agricultural Sciences, Raichur Karnataka 585104
*Corresponding Email: iabisheka@gmail.com

Abstract
Soil compaction is a major physical degradation process in agricultural soils that limits crop productivity, soil health, and ecosystem sustainability. It results primarily from mechanical pressure, often due to the use of heavy farm machinery, especially under moist soil conditions. Compaction alters the soil's physical structure, reducing pore spaces, water infiltration, and root penetration. This review discusses the principles of soil compaction, its causes, contributing factors, effects on plant growth and soil function, and management strategies. Emphasis is placed on sustainable practices including controlled traffic farming, cover cropping, subsoiling, and the application of organic matter to mitigate or reverse compaction. Understanding the dynamics and management of compaction is essential for maintaining productive and resilient agricultural systems.

Keywords: Soil compaction, sustainable agriculture, crop productivity, controlled traffic farming, soil health.

Introduction
Soil is a fundamental resource for food production and environmental sustainability. However, anthropogenic activities especially in mechanized agriculture have contributed significantly to soil degradation, notably compaction. Soil compaction reduces soil porosity, restricts root growth, and impedes air and water movement. These effects culminate in lower crop yields and deteriorated soil health. Addressing soil compaction through understanding its principles and causes, and implementing efficient management practices, is vital for the success of sustainable agriculture.

Principles of Soil Compaction
Soil compaction occurs when external pressure exceeds the soil's structural resistance, causing a rearrangement of soil particles into a denser configuration. The process primarily affects the topsoil and subsoil layers, and can be permanent or temporary depending on soil type, moisture content, and management practices.

Key characteristics of compacted soils:
- Reduced macroporosity
- Increased bulk density
- Decreased water infiltration and aeration
- Restricted root growth

Mechanics of compaction:
Compaction is governed by the principle of stress transmission through the soil profile. Heavier loads or repeated passes concentrate stress, especially in moist soils with low shear strength (Horn & Fleige, 2003).

Causes of Soil Compaction

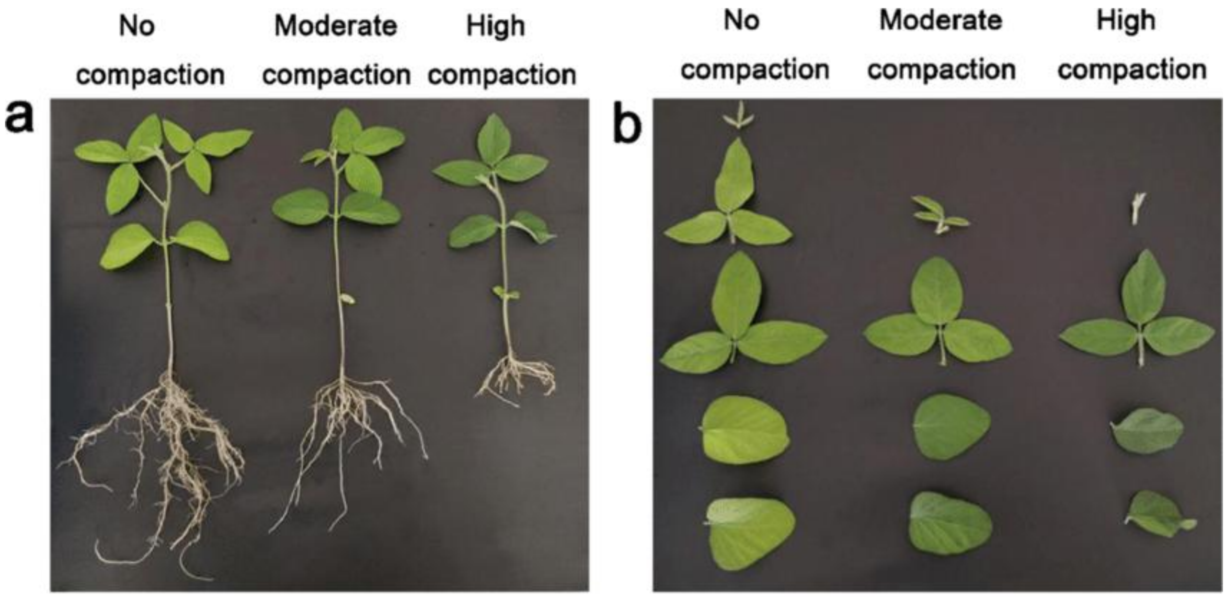
- **Heavy agricultural machinery**: Tractors, combines, and sprayers can exert pressures exceeding 200 kPa, particularly on wet soils.
- **Tillage operations**: Repeated tillage can disrupt soil structure and lead to plow pans—compacted subsoil layers.
- **Livestock trampling**: Grazing animals, particularly under wet conditions, contribute to surface compaction.
- **Natural consolidation**: In fine-textured soils, repeated wetting and drying cycles can naturally compact the soil.

Factors Affecting Soil Compaction

Factor	Effect on Compaction
Soil texture	Clay soils compact more due to plasticity
Moisture content	High moisture lowers soil resistance
Organic matter content	Higher levels improve aggregation
Load and pressure	Heavier and repeated loads cause deeper compaction
Tillage method	Deep tillage reduces, shallow tillage may increase compaction
Crop type and rotation	Deep-rooted crops alleviate compaction over time

Effects and Consequences of Soil Compaction

- **Reduced root growth**: Compaction impedes root penetration, limiting access to nutrients and water.
- **Lower water infiltration**: Water runoff and erosion increase due to reduced permeability.
- **Poor aeration**: Compacted soils lack oxygen, affecting microbial activity and root respiration.
- **Yield reduction**: Compaction can reduce yields by 10–50%, depending on severity and crop type (Raper & Kirby, 2006).
- **Soil structure degradation**: Long-term compaction destroys soil aggregates and promotes further degradation.



ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

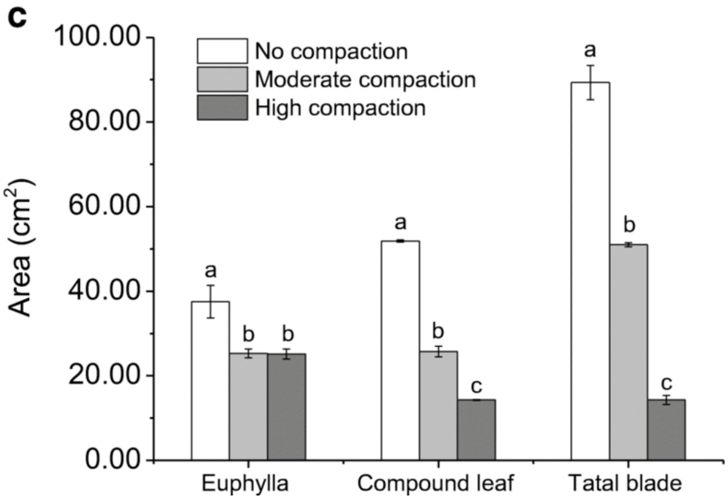


Fig 1. Impact of Soil Compaction on Roots

Management and Mitigation Strategies

Preventive Strategies

- **Controlled Traffic Farming (CTF)**: Limits traffic to specific lanes, preserving most of the field in uncompacted condition.
- **Avoid machinery use on wet soils**: Traffic during wet conditions should be minimized.

Remedial Strategies

- **Deep Tillage (Subsoiling)**: Breaks up hardpans and allows water and roots to penetrate deeper.
- **Cover Cropping**: Deep-rooted cover crops like radish or rye break compacted layers biologically.
- **Organic Matter Addition**: Improves soil structure and biological activity.
- **Agroforestry and Diversified Rotations**: Enhance soil resilience and minimize compaction risks.

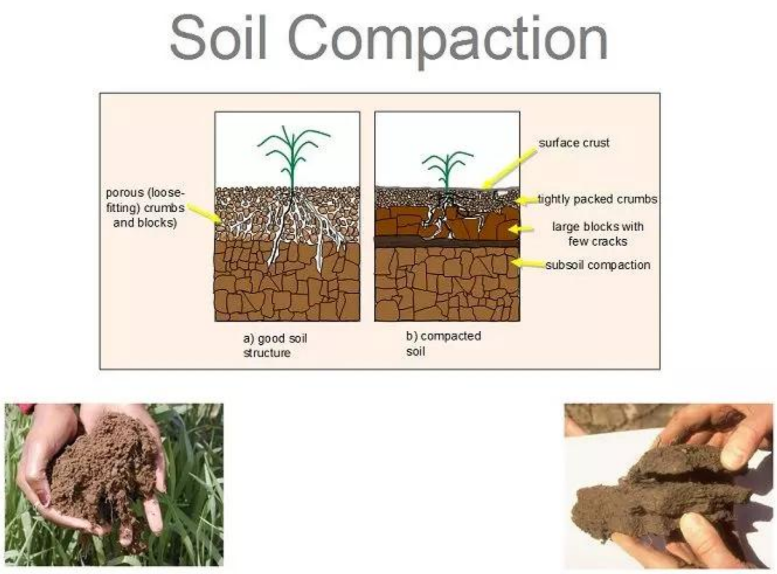


Fig 2. Soil Profile Showing Compaction Layers

Conclusion

Soil compaction remains a prevalent issue in global agriculture, compromising crop productivity and long-term soil health. Through a combination of preventive and corrective practices—including reduced traffic, biological remediation, and mechanical alleviation—farmers can manage compaction effectively. Adopting site-specific, sustainable solutions is essential to maintain soil productivity and ensure food security in an increasingly mechanized agricultural world.

References

Horn, R., & Fleige, H. (2003). A method for assessing the impact of mechanical loads on physical soil properties. *Soil and Tillage Research*, 73(2), 89–99. https://doi.org/10.1016/S0167-1987(02)00151-1.

Raper, R. L., & Kirby, E. A. (2006). Soil compaction: How to do deep tillage right. *Agronomy Journal*, 98(4), 1103–1112. https://www.agronomy.org/publications/aj/abstracts/98/4/1103.

Hamza, M. A., & Anderson, W. K. (2005). Soil compaction in cropping systems: A review of the nature, causes and possible solutions. *Soil and Tillage Research*, 82(2), 121–145. https://doi.org/10.1016/j.still.2004.08.009.

SARE (Sustainable Agriculture Research and Education). (n.d.). Compaction. https://www.sare.org/publications/building-soils-for-better-crops/compaction/

University of Minnesota Extension. (n.d.). Managing Soil Compaction. https://extension.umn.edu/soil-management-and-health/soil-compaction

USDA-NRCS. (2001). Soil Quality - Compaction. *Soil Quality Information Sheet*. https://www.nrcs.usda.gov

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/14/0625

CONSERVATION AGRICULTURE: A SUSTAINABLE PARADIGM FOR SOIL HEALTH, CLIMATE RESILIENCE, AND GLOBAL FOOD SECURITY

Mohd Anas[1]*, Asheesh Kumar[1], Sumaiya[2], G.K. Mahapatro[3] and C.M. Parihar[3]

[1]Ph.D. Scholar, Indian Agricultural Research Institute, New Delhi-110012
[2]M.Sc. Scholar, Maharaj Singh College, Saharanpur, UP- 247001
[3]Principal Scientist, Indian Agricultural Research Institute, New Delhi-110012
*Corresponding Email: entoanas12303@gmail.com

Abstract

Conservation Agriculture (CA), adopted on over 205 million hectares worldwide, promotes sustainable farming through minimal soil disturbance, permanent soil cover, and crop diversification. This review highlights CA's benefits, including a 50–90% reduction in soil erosion, a 0.3–0.6 t/ha/year increase in soil organic carbon, and a 30–45% improvement in water infiltration. CA contributes to climate change mitigation by sequestering 0.3–0.7 Pg C/year and cutting CO_2 emissions by 50–70%. Although initial yield reductions of 5–15% may occur due to transitional challenges, long-term productivity under CA stabilizes or surpasses conventional systems by 5–20%. Economically, CA can reduce fuel and labor costs by up to 50%, as evidenced in Brazil's soybean production. Nonetheless, challenges such as managing herbicide-resistant weeds and residue-borne diseases require integrated pest management strategies. To scale CA globally, advancements in precision agriculture, supportive policies like subsidies for no-till equipment, and research on socio-economic outcomes are essential. This article underscores CA's potential to advance SDGs 2 (Zero Hunger), 13 (Climate Action), and 15 (Life on Land), calling for interdisciplinary collaboration to overcome adoption barriers.

Keywords: Conservation agriculture, no-till farming, climate resilience, soil health.

Introduction

Modern agriculture faces a dual challenge: meeting the food demands of a growing population while mitigating environmental degradation. Conventional practices, characterized by intensive tillage, monocropping, and excessive agrochemical use, have degraded 33% of global soils, reduced biodiversity, and contributed 24% of anthropogenic greenhouse gas (GHG) emissions (FAO, 2023). Conservation Agriculture (CA), practiced on over 205 million hectares worldwide (Kassam *et al.*, 2023), redefines sustainability by harmonizing productivity with ecological stewardship. This review evaluates CA's scientific foundations, global applicability, and future potential, providing a roadmap for researchers, policymakers, and farmers.

Principles of Conservation Agriculture

CA rests on three interlinked principles:

Minimal Soil Disturbance (No-Till/Reduced Tillage):

- Eliminating plowing preserves soil structure, reduces erosion by 50–90%, and enhances carbon sequestration.
- Direct seeding or strip-till minimizes microbial disruption, fostering nutrient cycling.

Permanent Soil Cover:

- Crop residues or cover crops (e.g., legumes, grasses) reduce evaporation by 30%, suppress weeds, and protect against extreme temperatures.
- Residue retention (>30% cover) boosts soil organic carbon (SOC) by 0.3–0.6 t/ha/year.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Crop Diversification:

- Rotations (e.g., maize-soybean-wheat) break pest cycles, improve nitrogen fixation, and enhance resilience to market or climate shocks (Parihar *et al*., 2018).
- Intercropping systems (e.g., millet-cowpea) optimize resource use in smallholder farms.

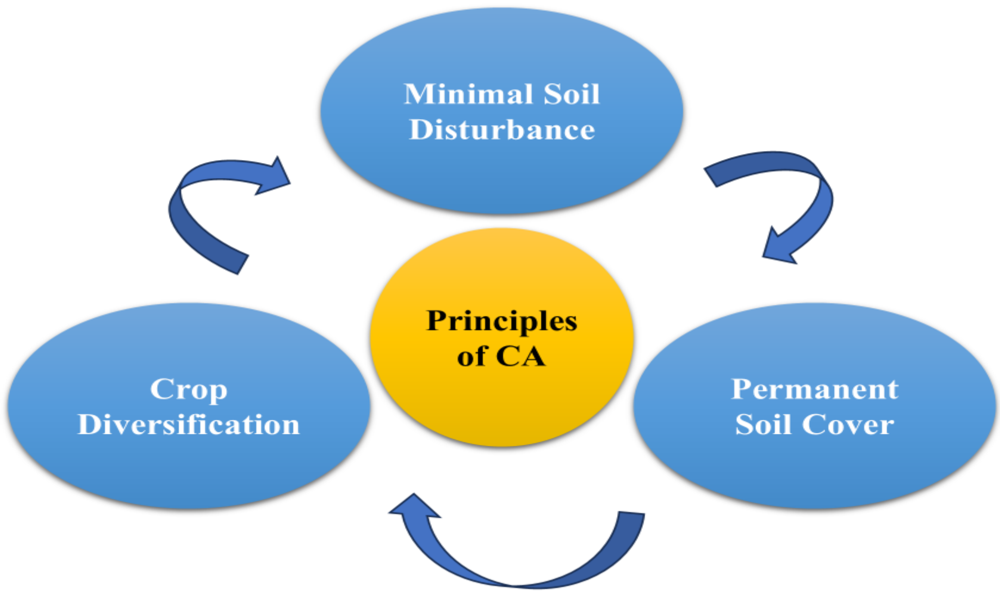


Figure 1 : Principles of Conservation Agriculture

Impacts on Soil Health and Biodiversity

Soil Physical and Chemical Properties

- **Aggregate Stability**: CA increases water-stable aggregates by 40–60%, reducing crusting and compaction.
- **Nutrient Availability**: Residue decomposition releases phosphorus and potassium, reducing fertilizer dependency.
- **pH and Salinity**: Mulching buffers pH fluctuations and lowers salt accumulation in arid zones.

Soil Biological Activity

- Earthworm populations rise 3–5 fold under no-till systems, enhancing porosity and organic matter turnover.
- Mycorrhizal fungi networks expand, improving phosphorus uptake.

Biodiversity Conservation

- CA fields host 30% more arthropods and birds compared to conventional systems.
- Cover crops like clover provide habitats for pollinators.

Climate Change Mitigation and Adaptation

Carbon Sequestration

- Global croplands under CA sequester 0.3–0.7 Pg C/year, offsetting 5–10% of annual GHG emissions.
- Long-term CA can store 1–3 t CO_2eq/ha/year in semi-arid regions.

GHG Emissions

- No-till reduces CO_2 emissions by 50–70% compared to conventional tillage.

- However, residue retention may increase N_2O emissions in poorly drained soils, necessitating nitrification inhibitors.

Climate Resilience

- CA enhances drought tolerance by increasing plant-available water by 20–40%.
- In Zimbabwe, CA maize yields surpassed conventional systems by 35% during droughts.

Water Use Efficiency and Crop Productivity

Hydrological Benefits

- Residue mulching reduces runoff by 50–80% and increases infiltration by 30–45%.
- In India's Indo-Gangetic Plains, CA wheat required 15–20% less irrigation (Jat *et al.*, 2005).

Yield Dynamics

- **Short-Term Gaps**: Initial yield reductions of 5–15% occur due to residue competition and weed pressure.
- **Long-Term Gains**: After 5–10 years, CA systems achieve yield parity or exceed conventional yields by 5–20%.

Socio-Economic Dimensions

Cost-Benefit Analysis

- CA reduces fuel and labor costs by 50% in mechanized farms (Kassam *et al.*, 2023).
- In Brazil, CA adoption saved $120–150/ha annually.

Adoption Barriers

- **Smallholders**: Limited access to no-till seeders and herbicides hinders uptake in Africa.
- **Cultural Factors**: Traditional tillage practices are deeply rooted in rural communities.

Case Studies

- **Brazil**: CA expanded to 32 million hectares, boosting soybean yields by 25%.
- **Zambia**: CA adoption increased household incomes by 30% through diversified cropping.

Challenges and Controversies

1. **Weed Management**: Heavy reliance on glyphosate raises concerns about herbicide resistance. Integrated approaches (cover crops, crop rotation) are critical.
2. **Disease Risks**: Residue-borne pathogens (e.g., *Fusarium spp*.) require strategic residue removal or biocontrol.
3. **Yield Debates**: Critics argue CA's benefits are context-dependent, with limited success in heavy clay soils.

Future Perspectives

Technological Innovations

- **Precision Agriculture**: Sensor-based tillage and variable-rate residue management optimize inputs.
- **Genetic Advancements**: Drought-tolerant cover crops and CRISPR-edited varieties enhance CA adaptability.

Policy Interventions

- **Subsidies**: Governments can incentivize CA through grants for no-till equipment (e.g., India's SMAM scheme) (Jat *et al.*, 2005).
- **Carbon Credits**: CA's sequestration potential aligns with the "4 per 1000" initiative.

Research Priorities

- Long-term studies on SOC saturation and GHG trade-offs.
- Socio-economic metrics for CA's gender equity and rural employment impacts.

Conclusion

Conservation Agriculture represents a paradigm shift toward resilient and sustainable food systems. By restoring soil health, mitigating climate change, and empowering farmers, CA aligns with SDGs 2 (Zero Hunger), 13 (Climate Action), and 15 (Life on Land). Scaling CA requires context-specific adaptations, robust policy frameworks, and global collaboration. This review underscores CA's transformative potential while calling for interdisciplinary research to address lingering knowledge gaps.

References

FAO (2023). *The State of Food Security and Nutrition in the World*.

Jat, M.L., Srivastva A, Sharma, S.K., Gupta, R.K., Zaidi, P.H., & Srinivasan, G. (2005). Evaluation of maize-wheat cropping system under double-no-till practice in Indo-Gangetic plains of India. *Soil and Tillage Research,* 9(2), 6-9.

Kassam, A. (2023). Conservation agriculture for regenerative and resilient production systems. In *Biological Approaches to Regenerative Soil Systems* (251-264). CRC Press.

Parihar, C. M., Yadav, M. R., Jat, S. L., Singh, A. K., Kumar, B., Pradhan, S., Chakraborty, D., Jat, M.L., Jat, R. K., Saharawat, Y.S., & Yadav, O. P. (2016). Long term effect of conservation agriculture in maize rotations on total organic carbon, physical and biological properties of a sandy loam soil in north-western Indo-Gangetic Plains. *Soil and Tillage Research*, 161, 116-128.

Parihar, C. M., Parihar, M. D., Sapkota, T. B., Nanwal, R. K., Singh, A. K., Jat, S. L., & Jat, M. L. (2018). Long-term impact of conservation agriculture and diversified maize rotations on carbon pools and stocks, mineral nitrogen fractions and nitrous oxide fluxes in inceptisol of India. *Science of the Total Environment*, *640*, 1382-1392.

Singh, V. K., Dwivedi, B. S., Singh, S. K., Majumdar, K., Jat, M. L., Mishra, R. P., & Rani, M. (2016). Soil physical properties, yield trends and economics after five years of conservation agriculture-based rice-maize system in north-western India. *Soil and Tillage Research*, 155, 133-148.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/15/0625

DELAY IN RIPENING OF FRUIT CROPS

Shaipharson Syngkon*

Research Scholar, Department of Pomology (Horticulture),
Nagaland University, SAS, Medziphema, Nagaland-797106
*Corresponding Email: syngkonshaipharson@gmail.com

Introduction

Fruits play a vital role in nutrition and they are rich source of vitamins, minerals, dietary fibers, different important carotenoids (lycopene, beta-carotene, xanthophyll etc.), flavonoids, phenolic and other phytochemicals (Schreiner and Huyskens-Keil, 2006). Owing to their antioxidant, anti-carcinogenic and anti-mutagenic activities, carotenoids and other phytochemicals provide protection against chronic disease states, different types of cancers, macular and cardiac vascular diseases and age related ailments (Blasa *et al*., 2010).

Fleshy fruits like apple, peach, pear, pineapple, watermelon and mango are commercially valuable as human food, eaten both fresh and as jams, marmalade and other preserves. These processes lead to changes in color, texture, aroma, taste, odor, and nutritional quality (Giovani *et al*., 2017) .

Studies have shown that ABA plays a crucial role in the ripening of non-climacteric fruits while, in climacteric fruits, the role of ethylene in the ripening is widely known. Recent studies showed ABA and melatonin have positive or negative interaction and influenced several physiological process including stress tolerance and fruit ripening (Xu *et al*., 2018).

Concept of Delay in Ripening

Ripening is a natural process that brings a series of biochemical changes, ethylene is a natural plant growth hormone having numerous effects on plant growth and development besides the regulatory role in ripening process of climacteric fruits (Bapat *et al*., 2010). Plant cells contain ethylene binding receptors that has an ethylene binding site, which gets activated by ethylene and triggers ripening action of fruits.

Some chemicals were found to block the response of basal level of ethylene in fruits and thus delayed the natural ripening process significantly (Kandungan *et al*., 2013, Osorio *et al*., 2013). These ethylene inhibitors reacts with the ethylene receptor and inhibits the action of ethylene.

Methods For Delaying in Ripening

Methylcyclopropene:

1-Methylcyclopropene (1-MCP) was reported to inhibit the ethylene action more effectively (Paul *et al*., 2012) and it can be used to delay the ripening process of various climacteric fruits. 1-MCP delayed ripening of ‘Tainung-1’ papaya fruit effectively without changing the quality of papaya. It was found to delay the softening process of papaya quite well; and the storage of fruits at low temperature after treatment was found to extend the post-harvest life effectively maintaining the quality of the fruit. However, the efficiency of 1-MCP in delaying ripening of tomato depends on concentration.

Salicylic Acid:

Salicylic acid (SA) is a ubiquitous plant phenolic compound that regulates a number of processes in plants and it is an important component in the signal transduction pathway. SA was found to inhibit the ethylene action on different climacteric fruits (Shafiee *et al*., 2010). It was reported to delay banana fruit ripening effectively. The major enzymatic antioxidants namely, catalase and peroxidase, was also found to be reduced in presence of SA during the ripening process of banana.

Gibberillic Acid:
Gibberellic acid (GA3) is a naturally-occurring plant growth hormone found in most plant tissues. It is involved in physiological processes such as flowering, seed set and fruit development, and is used in selected horticultural crops to manipulate flowering and fruit development. It was found that GA3 delayed the anthocyanin synthesis and chlorophylls degradation Post-harvest treatment of GA3 increased the quality of different climacteric fruits (Kandungan *et al*., 2013). Peach treated with GA3 maintained a higher firmness during storage at 2°C and the respiration rate and ethylene emission was also reduced significantly. Therefore, GA3 treatment seems to be effective in reducing the susceptibility of the fruits under unexpected mechanical damages. GA3 is also suitable for banana. Dipping of whole banana fruit in aqueous solutions of GA3 at concentrations from 10^{-5} to 10^{-2} M was reported to delay ripening of banana fruit effectively maintaining the quality of the fruit and thus increase shelf life.

Potassium Permanganate:
It has been proved in many scientific research experiments that KMnO4 decreases the ripening process of fruits. KMnO4 is a stable purple solid compound and is used to extend the shelf life of fresh produces. It reduces the level of ethylene in fruits by oxidizing to CO2 and H2O. Oxidation of ethylene by potassium permanganate results in carbon dioxide and H2O formation. It has been proved that with an increase in the quantity of KMnO4, level of ethylene gas is decreased and it was estimated that 20 gm of KMnO4 is able to reduce about 2.2% of ethylene (Correa *et al*., 2005).

Oxalic Acid:
Oxalic acid treatment decreases the deterioration of fruits throughout storage. Increased shelf life and lower decay rate were observed in mango fruits when treated with 5mm oxalic acid after harvesting and in controlled atmosphere storage.

Wu *et al*., (2011) treated plum fruits with oxalic acid @ 5mm and packed in polyethene bags and stored at 25°C for 12 days and found that oxalic acid treated fruits has more shelf life in comparison to control fruits. Treatment of oxalic acid @ 20 mm results in reduced respiration rate and declined production of ethylene in banana fruits in comparison to control.

Hydrogen Sulphide:
Hu *et al*., (2014) advocated that the shelf life of pear slices could be increased by the application of H2S by inhibiting developments of many fungal pathogens. Treatment with H2S @ 45 and 90 µmol L −1 delayed the maturation and senescence in case of kiwifruit (Zhu *et al*., 2014). Treatment of H2S with 1mm of sodium hydrosulphide results in delayed ripening of banana and deferred the senescence. Hu *et al*., (2014) showed that by the inhibition of synthesis of endogenous ethylene and regulating ethylene signal transduction exogenous H2S results in delayed fruit softening and the ripening process of tomato fruit at the time of storage. By regulating cell wall degrading enzyme genes and affecting ethylene signal transduction pathway genes, H2S delays the senescence and ripening of kiwifruit (Lin *et al*., 2020).

Coating with Waxes:
Coating is considered as one of the most popular techniques to prolong the post-harvest life of fruits. Beeswax-coated mango was found to have the longest shelf life with good quality as beeswax is an antioxidant with antimicrobial property. However,

the taste, color, aroma and flavor were found to be the best for starch coated fruits (Bibi and Baloch, 2014). Apples treated with hot air at 38ºC for 4 days and then coated with 1% chitosan before storage at 0ºC for 8 weeks, followed by further commercial shelf storage at 20ºC for 7 days is considered as an effective method to maintain the quality of Gala apples (Shao *et al*., 2012). Chitosan coating was found to delay fruit senescence and fungal decay of strawberry stored at 10ºC and 70 ± 5% relative humidity.

References

Bapat, V.A., Trivedi, P.K., Ghosh, A., Sane, V.A., Ganapathi, T.R., Nath, P. 2010. Ripening of fleshy fruit : Molecular insight and the role of ethylene. *Biotechnology Advances.* 28: 94-107.

Bibi, F., Baloch, M.K. 2014. Postharvest Quality and Shelf Life of Mango (*Mangifera indica* L.) Fruit as affected by various coatings. *Journal of Food Processing and Preservation.* 38:499-507.

Blasa, M., Gennari, L., Angelino, D., Ninfali, P. 2010. Fruit and vegetable antioxidants in health. pp. 37-58.

Corrêa, S. F., Da Silva, M. G., Oliveira, J. G. Gheysarbigi, S., Mirdehghan, S. H., Ghasemnezhad, M., and Nazoori, F. 2020. The inhibitory effect of nitric oxide on enzymatic browning reactions of in-package fresh pistachios (*Pistacia vera* L.). *Postharvest Biology and Technology.* 159: 110998.

Giovannoni, J., Nguyen, C., Ampofo, B., Zhong, S. and Fei, Z. 2017. The epigenome and transcriptional dynamics of fruit ripening. *Annual Review of Plant Biology*. 68: 61–84.

Hu, K.D., Wang, Q., Hu, L. Y., Gao, S. P., Wu, J., Li, Y. H., 2014. Hydrogen sulphide prolongs postharvest storage of fresh-cut pears (Pyrus pyrifolia) by alleviation of oxidative damage and inhibition of fungal growth. PloS One. 9(1): e85524.

Kandungan, K., Giberelik, A., Mangga, B., Indica, M., Tuai, L., Penyimpanan, S. 2 013. Postharvest Quality of Mango (*Mangifera Indica L* .) Fruit affected by different levels of gibberellic acid during storage. *Malaysian Journal of Analytical Sciences.* 17: 499-509.

Lin, X., Yang, R., Dou, Y., Zhang, W., Du, H., Zhu, L., and Chen, J. 2020. Transcriptome analysis reveals delaying of the ripening and cell-wall degradation of kiwi fruit by hydrogen sulfide. *Journal of the Science of Food and Agriculture*, 100 (5): 2280-2287.

Paul, V., Pandey, R., Srivastava, G.C. 2012. The fading distinctions between classical patterns of ripening in climacteric and non-climacteric fruit and the ubiquity of ethylene-An overview. *Journal of food science and technology.* 49: 1-21.

Schreiner, M., Huyskens K. S. 2006. Phytochemicals in fruit and vegetables: Health Promotion and postharvest elicitors. *Critical Reviews in Plant Sciences.* 25: 267-278

Shafiee, M., Taghavi, T.S., Babalar M. 2010. Addition of salicylic acid to nutrient solution combined with post harvest treatments (hot water, salicylic acid, and calcium dipping) improved post harvest fruit quality of strawberry. *Scientia Horticulturae.* 124: 40-45.

Shao, X.F., Tu, K., Tu, S., Tu, J. 2012. A Combination of heat treatment and chitosan coating delays ripening and reduces decay in "gala" apple fruit. *Journal of Food Quality.* 35: 83-92.

Wu, F., Zhang, D., Zhang, H., Jiang, G., Su, X., Qu, H. and Duan, X. 2011. Physiological and biochemical response of harvested plum fruit to oxalic acid during ripening or shelflife. *Food Research International*, 44(5), 1299-1305

Xu, L., Yue, Q., Xiang, G., Bian, F. E. & Yao, Y. 2018. Melatonin promotes ripening of grape berry via increasing the levels of ABA, H2O2, and particularly ethylene. *Horticulture Research*. 5: 41–51.

Zhu, L., Wang, W., Shi, J., Zhang, W., Shen, Y., Du, H., and Wu, S. 2014. Hydrogen sulphide extends the postharvest life and enhances antioxidant activity of kiwifruit during storage. *Journal of the Science of Food and Agriculture.* 94(13): 2699-2704.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/16/0625

VARIOUS EDIBLE FLOWERS AND THEIR IMPORTANCE

Nalanda Acharya*

Research Scholar, Department of Pomology and Postharvest Technology,
Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal-736165.
*Corresponding Email: nalandaacharya2018@gmail.com

Introduction

A plant's flowers are a vital component that contain a wide range of naturally occurring antioxidants, including carotenoids, polyphenols, and numerous other bioactive and nutraceutical substances. Since ancient times, edible flowers have been included into food preparation to enhance its nutritional value and sensory appeal. Since ancient times, edible flowers have played a significant role in human diet (Kelley *et al.,* 2003, Lim 2014). European, Asian, Oriental, Victorian English, and Middle Eastern cultures have all historically employed them in their cuisine *et al*., (Kaisoon *et al.,* 2012). In the past, people mostly ate flowers for their medicinal qualities rather than their nutritional content. Carotenoids, dietary fibers, fatty acids, flavonoids, isothiocyanates, phenolic acids, sterols, polyols, prebiotics/probiotics, vitamins, phytoestrogens, essential mineral elements, carbohydrates, and amino acids are among the significant bioactive and nutraceutical compounds found in wild and ornamental flowers, according to a number of recent studies (Kaisoon *et al.,* 2011, Cavaiuolo *et al.,* 2013, Lim 2014, Koike *et al.,* 2015). Edible flower consumption is rising globally (Kelley *et al.,* 2003, Lim 2014). Flowers are eaten in a variety of shapes, hues, and flavors to improve the nutritional value and flavor of meals (Lim 2014, Koike *et al.,* 2015).Salads, soups, entrees, desserts, and beverages all employ them as a garnish or ingredient (Kelley *et al.,* 2003). According to Kaisoon *et al.,* (2012), some flowers can be stuffed or used to stir-fry recipes. There are more than 80 species belonging to roughly thirty-two families that are categorized as edible flowers (Lim 2014). Among them, few species are as follows:

a) Heartsease (*Viola tricolor* L.)- Belonging to the family Violaceae, heartsease (*Viola tricolor* L.) according to Koike *et al.,* (2015) is a tiny, delicate flowers might be blue, yellow, purple, pink, white, or a combination of these colors. It is used to treat dyspepsia, high blood pressure, and skin conditions like inflammation, rashes, and eczema. Additionally, it can be used to treat rheumatoid arthritis, gout, stiff, aching joints, coughs, and colds (Vukics *et al.,* 2008a, Roberts 2014). The existence of flavonoid molecules is responsible for their biological actions, primarily their antioxidant qualities. according to reports, the main component is violanthin (Vukics *et al.,* 2008b, Koike *et al.,* 2015).
   The velvety texture and mildly lettuce-like flavor of V. tricolorblossoms are refreshing. They are used to decorate sweets, add garnishes to salads, soups, vinegars, and beverages (Creasy 1999, Koike *et al.,* 2015).
b) Common daisy (*Bellis perennis* L.)- Belongs to the Asteraceae family (Gudej and Nazaruk 2001). It has a long history of use in medicine and traditional remedies and can be found in meadows and lawns throughout Europe and the Mediterranean (Roberts 2014). The flowers of daisy rays might be white, pink, or a variety of red and purple colors (Lim 2014) The plant is commonly used as a laxative, diuretic, diaphoretic, and remedy for eczema, eye conditions, stomachaches, tonsillitis, common colds, and skin boils. It has antispasmotic, antiexudative, depressive, anti-inflammatory, and expectorant properties in traditional

medicine (Gudej and Nazaruk 2001, Nazaruk and Gudej 2001, Lim 2014, Morikawa *et al.,* 2015). Additionally, B. perennis's aerial portions are eaten as a vegetable (Kavalcıoğlu *et al.,* 2010). Most often used as a garnish on salads, soups, sandwiches, and steamed vegetables, common daisy petals have a mildly bitter flavor (Creasy 1999, Lim 2014).

c) The marigold - it is another significant genus in the Asteraceae family. For generations, marigolds were utilized as a safe medication. Marigold flower infusion is a secure diuretic, reducing water retention and swollen feet while eliminating toxins from the kidneys and bladder (Roberts 2014). Tagetes tenuifolia flowers are smaller than those of most other marigolds and can be yellow, orange, or bicolored. Lutein diesters and xanthophylls are abundant in Tagetes species' flowers (Deineka *et al.,* 2007).

d) Evening primrose (*Oenothera biennis L.*)- The Onagraceae family includes the evening primrose which has been used for ages to treat a wide range of illnesses. In addition to being used as an infusion for anxiety, panic attacks, and terror, it has also been used as a lotion and poultice for bruises and skin conditions, as well as for older women (Roberts 2014). Because evening primrose seeds contain γ-linolenic acid (GLA), which is utilized as a nutritional and medical supplement, they are typically grown as oil seed crops these days (Zadernowski *et al.,* 2002, Ghasemnezhad and Honermeier 2007). In cooking, teas, stews, and soups are enhanced with leaves and flowers. Additionally, they are utilized as garnishes and infusions (Roberts 2014).

e) Verbena- A genus of Verbenaceae family, consists of about 200 species worldwide. Cultivated garden verbenas, categorized as Verbena × hybrida, originate from hybridization among several species. They are popular and important ornamental plants (Tamura *et al.,* 2003). Verbena flowers can be eaten raw in salads, sandwiches or used as garnishes.

f) Begonias- Begonias are known for their anodyne, antiphlogistic, antispasmodic, astringent, ophthalmic, poultice and atomachic activities (Mlcek and Rop 2011). The brightly coloured flowers of Begonia have a delicious, light, lemon taste and crisp texture (Lim 2014). Their petals are used in salads and sandwiches, and as garnishes (Creasy 1999).

g) *Salvia splendens*- Belonging to the Lamiaceae family, is a plant originating from Brasil The flowers are red, white, salmon and purple (Wu *et al.,* 2009). The scarlet flowers of Salvia splendens contain salvianin (major), monardaein (minor) and their demalonyl derivatives, whereas the purple flowers of S. splendens contain salviadelphin and its demalonyl derivatives as well as dimalonylawobanin (Kondo *et al.,* 1989).

Conclusion

A vast variety of species from many different plant groups are edible flowers, which have aesthetic and practical us'//es in horticulture, medicine, and cooking. These blossoms, which are abundant in bioactive substances including flavonoids, antioxidants, and essential fatty acids, improve the appearance and taste of food while also promoting health and wellbeing. Traditional medicine has historically employed species including *Viola tricolor*, *Bellis perennis*, Tagetes, and *Oenothera biennis* to treat a variety of illnesses, from respiratory and digestive problems to skin disorders. Their growing popularity in modern gastronomy and natural healthcare highlights their potential as sustainable and value-added products. As consumer demand for plant-based, functional, and decorative ingredients rises, edible flowers stand out as a promising avenue for innovation in both the culinary and floriculture industries.

References

Cavaiuolo, M., Cocetta, G., Ferrante, A. (2013). The antioxidant changes in ornamental flowers during development and senescence. Antioxidants, 2, 132–155.

Creasy, R. (1999). The edible flower garden. Periplus, Singapore.

Deineka, V.I., Sorokopudov, V.N., Deineka, L.A., Tret'yakov, M.Yu. (2007). Flowers of marigold (Tagetes) species as a source of xanthophylls. Pharm. Chem. J., 41(10), 540–542.

Kaisoon, O., Konczak, I., Siriamornpun, S. (2012). Potential health enhancing properties of edible flowers from Thailand. Food Res. Int., 46, 563–571.

Kavalcıoğlu, N., Açık, L., Demirci, F., Semirci, B., Demir, H., Başer, K.H.C. (2010). Biological activities of Bellis perennis volatiles and extracts. Nat. Prod. Commun., 5(1), 147–150.

Kelley, K.M., Cameron, A.C., Biernbaum, J.A., Poff, K.L. (2003). Effect of storage temperature on the quality of edible flowers. Postharv. Biol. Tec., 27, 341–344.

Koike, A., Barreira, J.C.M., Barros, L., Santos-Buelga, C., Villavicencio, A.L.C.H., Ferreira, I.C.F.R. (2015). Edible flowers of Viola tricolor L. as a new functional food: Antioxidant activity, individual phenolics and effects of gamma and electron-beam irradiation. Food Chem., 179, 6–14.

Kondo, T., Yoshikane, M., Goto, T., Yoshida, K. (1989). Structure of anthocyanins in scarlet, purple, and blue flowers of salvia. Tetrahed. Lett., 48, 6729–6732.

Lim, T.K. (2014). Edible medicinal and non medicinal plants. Flowers. Vol. 7&8. Springer Science+Business Media, Dordrecht.

Mlcek, J., Rop, O. (2011). Fresh edible flowers of ornamental plants – A new source of nutraceutical foods. Trends in Food Sci. Tech., 22, 561–569.

Nazaruk, J., Gudej, J. (2001). Qualitative and quantitative chromatographic investigation of flavonoids in Bellis perennis L. Acta Pol. Pharm. – Drug Res., 58(5), 401–404.

Roberts, M. (2014). 100 Edible & Healing Flowers. Struik Nature, South Africa.

Tamura, M., Togami, J., Ishiguro, K., Nakamura, N., Katsumoto, Y., Suzuki, K., Kusumi, T., Tanaka, Y. (2003). Regeneration of transformed verbena (Verbena × hybrida) by Agrobacterium tumefaciens. Plant Cell Rep., 21, 459–466

Vukics, V., Kery, A., Guttman, A. (2008a). Analysis of polar antioxidants in heartsease (Viola tricolor L.) and garden pansy (Viola × wittrockiana Gams.). J. Chromatogr. Sci., 46, 823–827.

Wu, D.L., Hou, S.W., Qian, P.P., Sun, L.D., Zhang, Y.C., Li, W.J. (2009). Flower color chimera and abnormal leaf mutants induced by 12C 6+ heavy ions in Salvia splendens Ker-Gawl. Sci. Hortic., 121, 462–467.

Zadernowski, R., Naczk, M., Nowak-Polakowska, H. (2002). Phenolic acids of borage (Borago officinalis L.) and evening primrose (Oenothera biennis L.). JAOCS, 79(4), 335–338.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/17/0625

EFFECT OF BIO STIMULANT IN HORTICULTURAL SEEDS

S. Gomathi[1*] and R. Sindhu Lakshmi[2]

[1]M.Sc scholar Department of Seed Science and Technology,
AC&RI, Madurai -625104, Tamilnadu, India
[2]Research scholar, Department of Seed Science and Technology,
AC&RI, Madurai -625104, Tamilnadu, India
*Corresponding Email: gomathishivakumar53@gmail.com

Abstract

The use of bio stimulants in the treatment of horticultural seeds has demonstrated to enhancing seed germination, seedling strength, and overall plant establishment. These bio stimulants, which encompass microbial inoculants, humic acids, seaweed extracts, and amino acids, facilitate natural physiological processes that boost early plant growth without serving as direct nutrient sources. When used on seeds, these bio stimulants can improve root development, enhance the efficiency of nutrient uptake, and increase resilience to abiotic stressors such as drought and salinity, ultimately resulting in more robust and resilient plants. Studies suggest that seeds treated with bio stimulants may germinate more quickly, exhibit more uniform seedling emergence, and yield higher crop outputs. With ongoing advancements, bio stimulants have the potential to significantly contribute to sustainable horticultural practices, improving crop performance right from the seed stage.

Key word: abiotic stress, bio stimulant, germination, seaweed, yield

Introduction

In recent years, the rapid growth of the global population has led to an increasing demand for food worldwide, necessitating an enhancement of crop yields even in challenging conditions such as water scarcity, salinity, and rising temperatures. At present, there is a heightened focus on understanding how trees respond to these conditions to maintain crop productivity. Researchers are exploring new ingredients to support production systems for horticultural crops and mitigate the adverse effects of abiotic stresses, particularly drought and salinity Abobatta (2020). The use of bio stimulants has been shown to be particularly effective in aiding the recovery of various crops following exposure to water stress.

Bio stimulant products in horticulture are natural or chemical substances that enhance plant growth, stress tolerance, and nutrient uptake, promoting healthier and more productive crops. There is no doubt that for the horticultural industry to become more resilient and sustainable growers need to adopt a range of biological products including plant bio stimulants. Stimulating natural processes, quality bio stimulant products have been scientifically proven to enhance nutrient uptake and efficiency, tolerance to abiotic stress as well as crop quality. Horticultural crops, including fruits, vegetables, and ornamental plants, often face challenges related to climate change, soil degradation, and the increasing demand for sustainable production methods. Biostimulants offer a promising solution, enhancing the physiological processes of seeds and plants while reducing the reliance on chemical inputs. This article explores the role, mechanisms, and effects of biostimulants on horticultural seeds, backed by scientific evidence and practical examples.

Types of Bio stimulants

Bio stimulants are a diverse group of substances and microorganisms that enhance plant growth and resilience. Unlike fertilizers, which directly supply nutrients, biostimulants work indirectly by improving nutrient uptake, enhancing tolerance to abiotic stresses, or improving overall plant performance. Below is an exploration of the main types of biostimulants, their functions, and examples.

1. Humic and Fulvic Acids : Humic acid extracts from leonardite. Fulvic acids derived from composted materials.
2. Seaweed Extracts and Algae-Based Products : Extracts from kelp species like *Ascophyllum nodosum* and *Ecklonia maxima*.
3. Amino Acids and Protein Hydrolysates : Animal-based hydrolysates (e.g., collagen-derived products). Plant-based amino acids from soybean or corn.
4. Microbial Biostimulants : Mycorrhizal fungi inoculants. Biofertilizers containing nitrogen-fixing bacteria.
5. Plant Extracts and Phytochemicals : Extracts from *Moringa oleifera* or *Trigonella foenum-graecum*.
6. Inorganic Compounds : Potassium silicate sprays. Selenium-enriched fertilizers.
7. Beneficial Fungi : Products containing *Glomus intraradices* or *Glomus mosseae*.
8. Compost and Vermicompost Extracts : Compost teas. Vermicompost liquid extracts.
   Source: Abobatta (2020).

Mechanisms of Biostimulant Action

Seed Germination: Biostimulants improve water absorption and enzymatic activity during seed germination. Enhanced production of gibberellic acid promotes seed coat rupture and radicle emergence. (Drobek **et.al. 2019) Root Development**: Stimulation of auxin production enhances root elongation and branching. Improved nutrient uptake efficiency due to better root architecture. **Stress Tolerance**: Increased production of antioxidants mitigates oxidative stress caused by drought, salinity, and temperature extremes. Strengthened cell wall integrity protects against biotic stresses. **Nutrient Uptake and Utilization**: Biostimulants improve nutrient solubility and uptake through enhanced microbial activity and root exudates. **Hormonal Regulation**: Modulation of phytohormones like cytokinins, auxins, and abscisic acid enhances plant growth and stress response.

Applications of Biostimulants Biostimulants have various applications in agriculture and horticulture, particularly in improving seed germination, crop establishment, plant growth, nutrient uptake, and resistance to stress. One important application is seed coating, where biostimulants are applied directly to seeds to enhance early seedling growth and stand establishment. For instance, red clover and perennial ryegrass showed improved seedling growth and faster germination when coated with biostimulants compared to untreated seeds. Faster germination is especially useful in arid regions or areas with poor soil. Further research is needed to evaluate the cost-effectiveness of using materials like vermicompost and plant-based proteins as commercial seed treatments. In current seed industry practices, seed coatings often contain fertilizers and nitrogen-fixing bacterial inoculants such as Rhizobium, particularly for legumes like red clover.

(Drobek **et.al. 2019)** **Reported** another common method is seed soaking or priming, which enhances germination, plant stand, yield, quality, and stress resistance. This method influences various vegetative, physiological, biochemical, and molecular traits of the plant. Because seed priming is less labor-intensive and more cost-effective than other methods, it is well-suited for widespread adoption in the horticultural industry. It also improves the nutritional quality of produce. The most commonly used biostimulants in priming include humic acids, seaweed extracts, and liquid manure. In addition, foliar application is another effective method. Plant or seaweed extracts are sprayed directly on the leaves. A notable example is Kelpak SL, an extract from Ecklonia maxima, which was sprayed on Phaseolus vulgaris. Foliar application is often more effective than soil application, particularly when plants face environmental stress like frost.

For example, foliar application of a sewage sludge-derived bio-stimulant significantly increased macro- and micronutrient content in maize leaves. Nitrogen content in maize increased by 26% at 3.6 L/ha and 46% at 7.2 L/ha. The best time to apply foliar bio-stimulants is in the morning when stomata are open and the plant's assimilation rate is highest. Another method involves the use of seaweed biomass or meal, which is applied directly to the soil well before planting to enrich it. However, this method has logistical challenges and is mainly feasible near coastal regions where seaweed is readily available. The material must be mixed into the soil using ploughing or similar agro-technical practices. Lastly, biostimulants are used post-harvest. They can be sprayed on fruits to extend shelf-life and reduce spoilage. Extracts from Sargassum spp., Laminaria spp., and Ascophyllum nodosum have proven more effective than calcium chloride in reducing decay and improving storage quality in oranges by enhancing their resistance to mechanical damage and pathogens.

Benefits to using bio stimulants

Helping combat environmental stresses Bio stimulants can promote enhanced germination and root development, leading to increased vigour and greater stress resistance. An enhanced root system promotes more efficient nutrient and water uptake and translocation throughout the growing season. Boosting plant health and quality, Promoting growth and improving plant metabolism can benefit overall plant growth and health. In addition, providing a catalyst at specific developmental stages can lead to improved uniformity and overall plant quality. Encouraging plant growth Bio stimulants generally operate through different mechanisms compared to standard fertilizers, providing essential nutrients for plant metabolism that stimulate growth. Up regulating gene expression can have an effect on cell division and sizing, root and shoot growth, and reproductive development and timing. ***(Loeza-Lara*** **et.al,*****2024).***

Conclusion

In summary, biostimulants can be an important component of sustainable horticulture methods, promoting better crop establishment while decreasing reliance on chemical inputs. Nonetheless, the effectiveness of biostimulants can differ based on factors such as the plant species, the type of biostimulant, and the method of application. More research is required to standardize treatment processes and refine formulations that are customized for various horticultural crops, ensuring reliable advantages under a range of growing conditions. Biostimulants play a crucial role in enhancing the performance of horticultural seeds by improving germination, growth, and stress tolerance. As agriculture moves toward sustainability, the adoption of biostimulants is expected to grow. Continued research, standardization, and awareness will drive their successful integration into horticultural practices, ensuring higher productivity and environmental conservation.

References

Abobatta, W. F. (2020). Plant stimulants and horticultural production. *MOJ Ecol. Environ. Sci*, *5*, 261-265.

Drobek, M., Frąc, M., & Cybulska, J. (2019). Plant biostimulants: Importance of the quality and yield of horticultural crops and the improvement of plant tolerance to abiotic stress—A review. *Agronomy*, *9*(6), 335.

Loeza-Lara, P., Jiménez-Mejía, R., & Santoyo, G. (2024). The Effect of Biostimulants on Horticultural Crops. *Horticulturae*, *10*(10), 1086.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/18/0625

EMERGING PEST CHALLENGES: CLIMATE-SMART STRATEGIES FOR RESILIENT AGRICULTURE

Sake Manideep[1], Neha Singh[2], Amalendu Ghosh[2] and Amrita Das[2*]

[1]Division of Entomology, ICAR-IARI, New Delhi-12;
[2]Division of Plant Pathology, ICAR-IARI, New Delhi-12
*Corresponding Email: amritapatho@gmail.com

Introduction

Agriculture plays an essential role in human civilization, supporting food security, economic resilience and rural livelihoods. But agriculture is currently facing increasing risks and challenges as a result of climate change and increasingly rising pest pressures, which is one of the most complex and challenging issues. Climate change affects pests in a variety of ways by altering their life cycles, population dynamics, geographic spread and host choices. As climate change reshapes pest ecology, it further complicates already complicated pest problems, and permits invasive species to gain a foothold where they would not naturally establish. Salient characteristics of climate change, such as higher temperatures, erratic rainfall, long droughts, and more extreme weather, are all modifying pest ecology and threatening formal pest control techniques. Because pests can adapt faster than we can devise solutions, pest outbreaks have become both more frequent and more destructive, with pests causing as much as 40% of global food losses. It is necessary to improve pest renovation rates in order to secure food supplies, reduce inputs, and eliminate greenhouse gas emissions. Current control measures, which have relied on chemicals to manage and mitigate pest attacks, are becoming increasingly ineffective. Climate-smart pest management is a systems-level approach that blends ecological principles, technology and complemented strategies in a way that reinforces resilient and sustainable agricultural systems under climate change conditions.

Pest threats under the changing climate

Climate change has rendered pest behaviour unpredictable. The accelerated rates of pest development and increased populations due to higher temperatures, as well as pest movements previously prevented by geo-political and climate constraints, have shifted the pests into regions, their population established, where formerly they have been unsuccessful in establishing their populations, such as fall armyworm moving from the Americas to Africa, Asia, and Oceania, and *Thrips palmi* moves beyond Asia. These shifts disrupt predator-prey balances, leaving crops vulnerable. Unstable weather makes it harder for farmers to predict and manage pest outbreaks effectively. The following factors are accountable for increasing pest threats under changing climatic conditions:

Alteration in pest populations

Increasing temperatures as a consequence of climate change are speeding up pest development time, which leads to increased generation numbers per season and to greater migration rates. Insects such as aphids and mites are not only developing faster, but they are developing rapidly on crops they have never utilized before, causing greater damage. In addition, tropical pests are moving into temperate climates, placing additional threat to crops that previously did not have any threat. For example, the introduction of the sugarcane woolly aphid (*Ceratovacuna lanigera*), following its 2002-2003 outbreak in Karnataka and Maharashtra, caused extreme infestations leading to crop losses of up to 30%, with climate change signifying the growing risk of environmentally driven pest outbreaks.

Disrupted predator-prey relationships

Climate change may disrupt natural enemies like predators and parasitoids that help keep pest populations in check. Impacts on temperature and rainfall may lead to mistakes in their timing. For example, aphids may emerge earlier in the spring due to warmer conditions and this desynchronization may lead to the parasitoids not timing their life cycle appropriately and there could be reduced pest control. Some beneficial insects, such as lady beetles and wasps, are slow to adjust to climate effects, leaving crops vulnerable to pest infestations. On the other hand, some beneficials may do well under warmer conditions, demonstrating that climate change responses are species and environment dependent. Thus, while desynchronization can disrupt pest control, the overall impact is species-specific and influenced by broader environmental conditions.

Unpredictable outbreaks

Erratic weather patterns, such as sudden droughts and floods, create favourable conditions for unpredictable pest outbreaks. Secondary pest outbreaks often occur when inter-pest competition is reduced or eliminated. For example, cutworms, typically minor pests, can cause severe damage to young crops under favorable conditions like new planting or suitable weather. Similarly, locusts may become highly destructive following environmental shifts such as droughts followed by heavy rainfall.

Increased incidence of vector-borne diseases

Warmer temperatures, changing rainfall patterns and altered humidity can expand the geographic range and activity periods of disease vectors, such as aphids, whiteflies, thrips, leafhoppers, etc, leading to an increased incidence and spread of plant and animal diseases. Increase in sucking pest incidence and geographical spread is a concern under changing climate that leads to emergence and re-emergence of diseases.

Increased risk of invasive species

Climate change creates favourable conditions for invasive pests to establish and spread in new regions, posing significant challenges to local ecosystems and agriculture. For example, the invasion of rugose spiralling whitefly in the Indian subcontinent has severely affected plantation crop production. Similarly, the fall armyworm (*Spodoptera frugiperda*), a highly destructive maize pest, has rapidly spread in India and beyond due to its adaptability to warmer climates. Climate change has also intensified infestations of other pests like mealybugs, fruit flies, and the diamondback moth (*Plutella xylostella*), which are now more frequent and severe.

Principles of climate-smart pest management (CSPM)

Climate-smart pest management (CSPM) integrates sustainable agricultural practices with ecological principles to mitigate the risks posed by changing pest threats. It emphasizes sustainably increase agricultural productivity and incomes, enhance resilience to climate change and its effects (including altered pest dynamics), and reduce and/or remove greenhouse gas emissions, where possible.

Key strategies of CSPM include

Early warning systems: CSPM emphasizes the importance of monitoring pest populations and environmental conditions in real time. Climate data such as temperature, precipitation, humidity combined with pest population data can improve predictions of pest outbreaks and shifts in pest behavior.

Integrated Pest Management (IPM): CSPM strongly relies on the principles of IPM, which involves a holistic and ecological approach to pest management. This includes:

- **Prevention:** Develop a proactive plan to avoid pest infestations: use pest-resistant types, crop rotation, keep plants healthy, planting times, and adding nutrients to the soil.
- **Monitoring:** Regular inspections are necessary to determine the pest population and provide information to make decisions on pest control options with advanced technology, like sensors, drones, and AI powered tools.
- **Economic threshold levels:** Using pest management only when pest population levels have the potential to cause a level of economic damage that dictates pest management intervention will help avoid unnecessary management. Chemical pesticides should be used judiciously to slow resistance development, preserve beneficial organisms, and minimize ecological harm
- **Multiple Tactics:** Employing a combination of biological, cultural, physical, and chemical control methods in a way that minimizes environmental and health risks.

Use of climate-resilient crops

The evaluation and release of crop varieties that will be both abiotic stress- and biotic pressure-resilient is also a critical step in CSPM. Climate-resilient crops could diminish crop vulnerability to pests and diseases, reducing the need for pest control measures.

Diversified farming systems

Encouraging agricultural diversity is a fundamental principle of CSPM. Practices such as crop rotation, polyculture, agroforestry, and mixed farming can disrupt the build-up of pest populations by attacking pests that have become resilient to certain crops and also contributes to improving soil health and ecosystem resilience. For instance, a potato farmer implemented a zero-tillage integrated pest management (IPM) system utilizing rice straw mulch. This approach led to significant reductions in labor, water consumption, and dependence on pesticides and fertilizers, while boosting net profits by approximately 40%. Additionally, beneficial insects played a crucial role in pest control, naturally managing pest populations within the farming system.

Technologies supporting CSPM: Advancements in technology are playing a crucial role in CSPM, enabling farmers to predict, monitor, and control pest infestations in more sustainable and efficient ways. These innovations help mitigate climate-related pest challenges while reducing environmental impact.

- Remote sensing and GIS mapping help monitor pest migration patterns, geographical expansion, and long-distance migration.
- AI-based pest forecasting models can analyze climate data, historical pest outbreaks, and environmental factors to predict future infestations.
- Automated pest monitoring devices use sensors and cameras to detect pest presence and activity in real time.
- RNA interference (RNAi) technology disrupts pest gene expression, providing a precise and sustainable method for management of pest population.
- Gene-edited crops that can withstand biotic as well as abiotic stress and helpful for sustainable management of crop health.

Knowledge sharing and capacity building: Effective CSPM necessitates knowledge exchange and capacity building among farmers, extension workers, and researchers to understand the links between climate change and pest dynamics and to adopt suitable management techniques. This involves utilizing both digital and traditional advice services.

Farmer education and capacity building: Training programs and workshops empower farmers with knowledge of climate-smart practices and technologies. Collaborative networks allow farmers to share experiences and access resources. Awareness and capacity building of the stakeholders are necessary for successful adoption of the CSPM technologies like gene-edited crops, RNAi pesticides, etc.

Policy and institutional support: Creating an enabling environment through supportive policies, regulations, and institutional frameworks is essential for the widespread adoption of CSPM practices. This includes investing in research, extension services, and infrastructure for monitoring and forecasting.

Path forward

Climate-Smart Pest Management encourages integrated, various, operational methods implemented at the farm and landscape level that reduce climate impacts and improve resilience. Climate-smart pest management is crucial in protecting agricultural productivity and biodiversity in a changing climate. Governments, research organizations, and stakeholders must collaborate in order to develop and distribute innovative solutions. Research, technology, and systems that assist farmers must also be invested in. This approach not only protects crops but also ensures the well-being of ecosystems and farming communities, paving the way for a resilient and food-secure future.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/19/0625

AGRIVOLTAICS AND AGRICULTURAL ELECTRIC VEHICLES TOWARDS SELF SUSTAINABLE AGRICULTURAL OPERATIONS

Jyotirmay Mahapatra[1*], Vikas Pagare[2] and Abhishek Patel[3]

[1]College of Agricultural Engineering and Technology, Odisha University of Agriculture and Technology, Bhubaneswar-751003
[2]ICAR- Central Institute of Agricultural Engineering, Nabi Bagh, Bhopal-462038
[3]Department of Farm Machinery and Power Engineering,
College of Agricultural Engineering and Post-Harvest Technology, CAU, Imphal-737135
[*]Corresponding Email: jyotirmayfmpe@gmail.com

Introduction

Agrivoltaics integrates solar photovoltaics in agricultural land. The same land is thus utilised for dual purpose as energy generation and crop production. The land it utilised efficiently in this way in comparison to whole land dedicated to only crop production or only solar photovoltaics (PV) installation. This new method of cropping comes with number of opportunity as well as challenges.

Opportunities

- The shade provided by solar panels protects crops from excessive sunlight and heat stress, especially in tropical and arid regions. This creates a cooler microclimate, improving crop quality and reducing water evaporation.
- Solar panels in agrivoltaics systems produce clean and sustainable energy, reducing dependence on fossil fuels. Farms can become energy self-sufficient, with surplus energy sold to the grid, creating an additional income source.
- Shaded conditions reduce evaporation rates, conserving irrigation water. This is particularly beneficial in water-scarce areas.
- Crops like lettuce, spinach, strawberries, and herbs thrive under moderate shading provided by solar panels. Partial shade can improve growth conditions and reduce stress for these crops, leading to higher yields.
- Diversified Income Streams: Farmers earn from both crop production and solar energy generation. It offers energy independence and additional financial security, especially in regions with erratic crop yields.
- Solar panels act as a physical barrier, protecting crops from hail, heavy rainfall, or strong winds, thereby reducing damage and losses.
- Crops below the solar panels cool the environment around them, which can enhance the efficiency of solar panels by reducing their operating temperature.
- Farms can use solar energy to power pumps, machinery, and electric vehicles, significantly reducing operational costs. Systems can be paired with batteries for reliable energy storage, enabling nighttime or off-grid operations.

Challenges

- Cost of Solar Panels and Infrastructure: Setting up an agrivoltaics system requires substantial capital for solar panels, mounting structures, and electrical systems.
- Reduced sunlight under panels can affect photosynthetic activity in certain crops. Crops requiring high sunlight intensity, such as wheat, rice, or maize, may experience reduced

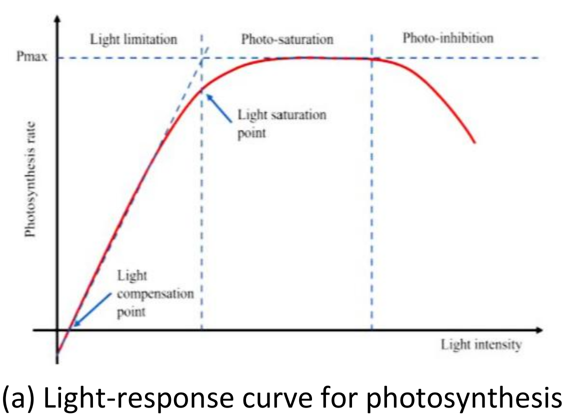
growth and lower yields under partial shade. Hence farmer need to adopt alternate suitable crop and cropping pattern.

- Dust accumulation on panels, especially in dry climates, can reduce energy efficiency. Cleaning the panels frequently may lead to increased water use. Crop Management: Working under solar panels requires specialized machinery or manual effort, which can increase labor costs and time.
- In the event of storms or strong winds, solar panels and their mounting structures may collapse, damaging crops and infrastructure.
- Animal Interference: Grazing animals can damage solar panel installations or cables in open agricultural fields.

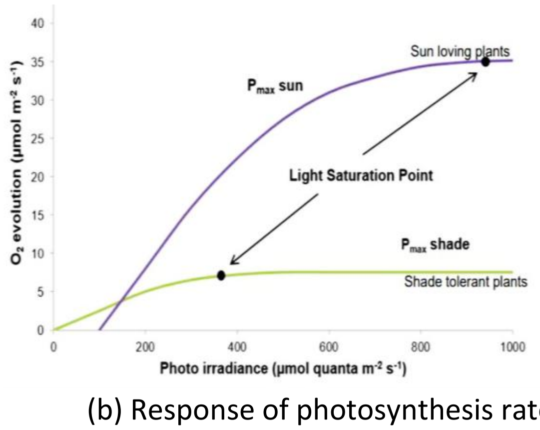
Crop Selection, Lay Out and Design

According to Lu et al. (2022) Photosynthetic Active Radiation (PAR) is essential for canopy photosynthesis and sub-divided into direct, diffused, and reflected radiation. Per unit of PAR, diffuse PAR contributes to a greater photosynthetic rate than direct PAR. While APV panels will obstruct part of solar radiation based on their density during a full sunny day, diffused solar radiation contributes towards photosynthesis.

The variety of crops that can be planted under PV modules need to have a certain ability to adapt to the light environment of corresponding area. In the effective period of crop growth, light compensation point (LCP), light saturation point (LSP), PAR, sunshine hours can be references to crops selection. The level of light compensation point is one of signs that plants can grow under low light intensity, which is also an important critical point for plant growth and development Laub et al., 2022. LCP and LSP generally change with the plant species, different parts of the same plant, growth and development stage, individual and group, outside temperature conditions (Laub et al., 2022). In general, plants with high saturation and high compensation point are positive or positive shade-tolerant plants and those with lower saturation and lower compensation point are negative or negative shade-tolerant palnts. Light saturation point for sun-loving plants would be more than shade-tolerant plants as portrayed in Fig. 7(b), thus shade loving plants can flourish under low intensity of light. Wang et al., 2017 classified different crops based on the demand of sunlight into three major categories (Class- I, II and III) as given in Table 1. Generally, C4 plants thrive under full sun while C3 plants are shade tolerant.



(a) Light-response curve for photosynthesis



(b) Response of photosynthesis rate Against light intensity

Fig 1. Relation between light intensity and photosynthesis

Table 1 Crops segmented into different class as per their requirement of sunlight (Wang et al., 2017)

Class	Species (Cultivar)		
III	Cucumber (Xintai mici)	Tomato (Zhong Shu No.4)	Potato (Tai Shan No.1)
	Cabbage (Zhong gan No.11)	Chinese chive (791)	Pakchoi (Shanghai qing)
	Lettuce (Ji nan Lettuce)	Spinach (Yuan ye)	Snapbean (Fengshou No.1)
	Eggplant (Luqie No.1)	Watermelon (Fengshou No.2)	Muskmelon (Qitian No.1)
	Pepper (Qie men pepper)	Radish (Luluobu No.1)	White gourd (Fen pi)
	Onion (Ziluo onion)	Sponge gourd (Ordinary)	Balsampear (Bincheng)
	Leaf lettuce (Boli)	Pumpkin (Yunnan black seeds)	Carrot (Wuchun shen)
	Chinese plate cabbage	Lentil (Green lentil)	Taro (Duozu Taro)
	Cauliflower (French snow ball)	Asparagus bean (Zhijiang No.28)	
	Garlic (Cang shan)	Celery (America celery)	
	Welsh onion (Zhang qiu)	Leaf lettuce (Boli)	
II	Onion (Ziluo onion)	Carrot (general)	Potato (Tai Shan No.1)
	Ginger (Laiwu ginger)	Taro (Duozu Taro)	Water spinach (White flower)
	Pepper (general)	Chinese cabbage (Lubai)	
I	Oyster mushroom	Garlic (general)	Malabar spinach
	Hotbed chives	Crowndaisy chrysanthemum	Some edible mushroom

Different types of structure and designs are adapted based on crop, price, land area, and location. Table 2 summarises these designs, along with their advantages and limitations.

Table 2. Solar Panel Structures and Arrangements in Agrivoltaics

Type	Crop	Advantages	Limitations
Fixed Tilt	Shade-tolerant crops	Simple and cost-effective	Static shading
Adjustable Tilt	Field crops	Seasonal optimization	Costlier than fixed systems
Single-Axis Tracking	Fruit-bearing crops	Higher energy yield	Requires additional space
Dual-Axis Tracking	High-value crops	Maximum energy efficiency	Expensive
Elevated Structures	Tall crops	Allows machinery operation	High installation cost
Vertical Structures	Orchards and vineyards	Saves land space	Lower energy capture
Semi-Transparent Panels	Shade-tolerant vegetables	Balanced light and energy use	Expensive
Movable/Retractable Panels	Sensitive seasonal crops	Adaptable to crop needs	Complex design

Type	Crop	Advantages	Limitations
Dynamic Systems	Precision farming crops	Smart optimization	High initial investment
Floating Solar	Aquaculture-integrated crops	Saves land and reduces water evaporation	Limited to water-adjacent fields

Advance features in agrivoltaics

Recent advancements in agrivoltaics technology for better and efficient adaptation includes the following:

- Semi-transparent solar panels allow partial sunlight to pass through while generating electricity.
- Greenhouses integrated with semi-transparent solar panels. Perovskite solar cells are lightweight and flexible solar cells with high efficiency.
- bifacial solar panels generate energy from both sides by capturing sunlight and reflected light from the ground.
- Solar panels equipped with tracking systems that adjust their orientation based on sunlight.
- Smart technologies that use artificial intelligence and IoT for real-time monitoring and optimization of energy and crop production.
- Irrigation system can be used to clean solar panels while drained water from panels is used for irrigation (Ravi et al., 2016).

Integration of Electric Agricultural Vehicles and Advantages

Electric agricultural vehicles not only reduce greenhouse gas emission but enable farm equipment to be smart. Microcontroller based intelligent farm machinery as well as electric motor based precise actuation and control need electric power supply. Farm equipment can be integrated with IoT for real time monitoring using sensors, storage device, personal smart device (computer/ mobile phone), and actuators (Mahapatra et al., 2024). Variable rate technology can be easily integrated to electric agricultural vehicles. Besides this electric equipment are easy to adjust as per requirement. Mahapatra et al., 2024 stated that demand for electrically powered and easily adjustable farm equipment will rise with newly evolving electric tractors and solar-powered or hybrid agricultural vehicles. Electric tractors reduce the health issues caused due to noise, vibration, toxic emissions in conventional engine tractors. Electric agricultural vehicles can be developed as remote controlled or autonomous.

Figure 2. Advantages of Integrated application of electric agricultural vehicle and agrivoltaics

Electric agricultural vehicles can be charged directly in the agricultural field reducing requirement of large battery capacity, idle travel to charging station, and dependence. Low-capacity alternate batteries may be used reducing initial cost of the vehicle. Remote and hilly areas having no nearby electric supply can use such electric vehicles while using agrivoltaics to charge. However, these electric vehicles required to be designed while considering solar PV structure (height, row to row distance) as well as crop height.

Conclusion

Agrivoltaics can provide additional assured income to the farmer besides crop production. Appropriate design, structure, solar panel, crop selection while considering land area, location, land topography, soil type, soil nutrients, rainfall pattern, local climate, cropping season, solar angles, common natural hazards and money to be invested are important to earn profit. The integration of electric agricultural vehicles has number of potential benefits as discussed. The initial price of these vehicles can be significantly reduced with low-capacity batteries, as alternate batteries can be charged in the farm land itself. Farmer can reduce operational cost substantially by mechanising operations, avoiding health issues, adopting precision agriculture, charging vehicles from generated electricity, reducing idle travel, minimising timeliness cost, lowering repair and maintenance cost through use of electric vehicles along with agrivoltaics for agricultural operations.

References

Laub, M., Pataczek, L., Feuerbacher, A. *et al.* Contrasting yield responses at varying levels of shade suggest different suitability of crops for dual land-use systems: a meta-analysis. *Agron. Sustain. Dev.* **42**, 51 (2022). https://doi.org/10.1007/s13593-022-00783-7

Lu, S. M., Zainali, S., Stridh, B., Avelin, A., Amaducci, S., Colauzzi, M., & Campana, P. E. (2022). Photosynthetically active radiation decomposition models for agrivoltaic systems applications. *Solar Energy*, *244*, 536-549. https://doi.org/10.1016/j.solener.2022.05.046

Mahapatra J, Tiwari PS, Singh KP, Nandede BM, Sahni RK, Pagare V, Singh J, Shrinivasa DJ, Mandal S. An Adjustable Pneumatic Planter with Reduced Source Vibration for Better Precision in Field Seeding. *Sensors*. 2024; 24(11):3399. https://doi.org/10.3390/s24113399

Mahapatra, J., Sahni, R.K., Sahoo, P.K., Shrinivasa, D.J. (2024). IoT-Based Real-Time Farm Management System for Smart Agriculture. In: Chouhan, S.S., Saxena, A., Singh, U.P., Jain, S. (eds) Artificial Intelligence Techniques in Smart Agriculture. Springer, Singapore. https://doi.org/10.1007/978-981-97-5878-4_16

Ravi, S., Macknick, J., Lobell, D., Field, C., Ganesan, K., Jain, R., ... & Stoltenberg, B. (2016). Colocation opportunities for large solar infrastructures and agriculture in drylands. *Applied Energy*, *165*, 383-392. https://doi.org/10.1016/j.apenergy.2015.12.078

Wang, D., Sun, Y., Lin, Y., & Gao, Y. (2017, June). Analysis of light environment under solar panels and crop layout. In *2017 IEEE 44th Photovoltaic Specialist Conference (PVSC)* (pp. 2048-2053). IEEE. https://doi.org/10.1109/PVSC.2017.8521475

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/20/0625

ENTOMOPATHOGENIC NEMATODE (EPN) FOR THE MANAGEMENT OF ROOT GRUB (*Basilepta fulvicorne*) IN CARDAMOM (*Elettaria cardamomum*)

Seema Yadav[1*], B. L. Baheti[2], Dinesh Kumar Yadav[3] and Rajendra Yadav[4]

[1]Department of Nematology, Rajasthan College of Agriculture,
MPUAT Udaipur, 313001, India
[2]Professor, Department of Nematology, Rajasthan college of Agriculture,
MPUAT, Udaipur, Rajasthan, 313001, India
[3]Department of Entomology, College of Agriculture Sriganganagar, SKRAU,
Bikaner, 334006, India
[4]Department of Entomology, CPCA, Sardarkrushinagar Dantiwada Agricultural university,
Gujarat, 385506, India
*Corresponding Email: ssy.seema@gmail.com

Abstract
Cardamom (*Elettaria cardamomum*) known as the queen of spices. Cardamom is an important plantation crop of India. Cardamoms are the dried fruits of perennial herbs. Root grub is a serious pest damaging the roots of cardamom. Nutrient uptake is reduced due to root damage leading to yellowing of leaves; the pest problem is severe in less shaded area. Entomopathogenic nematode (EPN) as component in IPM. Entomopathogenic nematodes can be an alternative to the pest control, mainly because of their eco-friendly nature and are compatible with a wide range of chemical and biological pesticides used in IPM programs. EPNs constitute a cost-effective, value-added approach to promote sustainable agriculture in small cardamom plantation.

Key words: Cardamom, Entomopathogenic nematodes, Root grub, Integrated Pest Management, *Steinernema* and *Heterorhabditis*

Introduction

Integrated pest management (IPM) is an ecosystem-based pest suppression that integrates practices to keep the pest population below economic threshold level (ETL). In the recent past, use of entomopathogenic nematode (EPN) as component in IPM is gaining momentum in order to avoid insecticide resistance, pest resurgence and pesticide residues. Nematodes that cause disease through symbiotic bacteria within an insect and have the ability to kill insect pests are referred as entomopathogenic nematode. EPN belonging to *Steinernema* and *Heterorhabditis* genus have potential to infect insect pests and have been demonstrated to control pests like root grubs in high value crops including cardamom. The third stage infective juveniles (IJs) of EPN survive outside an insect host and move from one insect to another in the soil. The IJs of steinernematids and hetrorhabditis enter a living host and release symbiotic bacteria of the genus *Xenorhabdus* and *Photorhabdus* respectively. The bacteria kill the host quickly within two to three days and emerging nematodes feed on the insect cadaver and digested tissues. The nematodes go through two or more generations, producing new IJs which enters into the soil as host resources are depleted. Safe to ecosystem, short life cycle and easy multiplication are some of the advantages of EPNs. Among various pests of cardamom, root grub is a key pest which feeds on roots of cardamom resulting in deterioration of palm health and production potential. The perennial nature of the crop and abundance of canopy levels helps to maintain microclimatic conditions which act as a favourable niche for the establishment of EPN in cardamom based ecosystem.

Mass production of EPNs

Entomopathogenic nematodes are easily multiplied on larvae of Greater wax moth, *Galleria melonella* because of its high susceptibility to EPN and ease in rearing under laboratory conditions. Around 250 to 300 IJs of EPN is inoculated on fully grown larvae (10 larvae) in each petri plate. After two to three days, discolored dead larvae are collected, rinsed in water, incubated for three days and placed on white trap for emergence. Nematodes harvested from white traps are cleaned and packed in polypropylene covers/flasks. These cleaned nematodes are ready for field application and can be stored under ambient temperature upto three months and shelf life can be extended upto six months at controlled conditions of 15-20°C.

Grubs in cardamom garden

Root grub, *Basilepta fulvicorne*: *Chrysomelidae* are found infesting the roots of cardamom particularly in the sandy and sandy loam soils. Peak population is observed during September to February which causes damage to cardamom as well as intercrops grown in cardamom based cropping system. cardamom growing regions is Kerala. Large scale and non judicious usage of insecticides have resulted in development of resistance, escalation of cost of production and environmental pollution. On the other hand, entomopathogenic nematodes can be an alternative to the pest control, mainly because of their eco-friendly nature and are compatible with a wide range of chemical and biological pesticides used in IPM programs.

Root grubs damage roots of cardamom, it was identified as a major pest from late 1980s. The incidence of the pest was high in areas with less shade where adult beetles settle on cardamom leaves only on less shaded areas (for taking energy from sunlight). Laying eggs in such areas leads to higher incidence of root grub and greater damage on roots. The crop loss is estimated to range between 29 to 66 precent depending on the number of grubs feeding on a plant root.

Eggs of root grub are laid on hanging dry leaves of cardamom. Upon hatching the grubs fall to the root zone of cardamom plant and start feeding on the roots. These grubs grow by feeding for about 45 to 60 days and become mature grubs. The life cycle/stages of the pest consists of beetles (small metallic green, brown or blue), grub (larva), pupa and beetles. During the grub stage, the female beetle lays eggs on dry hanging leaves of cardamom (one beetle lays up to 290 eggs), then the eggs hatch to become tiny 'C' shaped grub which drops down on the soil at the plant's base, then the grub start feeding on the roots and damage them. This process takes about 45 to 60 days for the grub to become mature and pupates in an earthen cocoon. The pupa emerges from soil as adult beetles around March-April (first generation) and then in August (second generation). So, there are two seasons of root grub damage on cardamom roots: April end to July and September to January-February.

Integrated Pest Management

- Periodical digging, hoeing and ploughing to reduce the root grub population by exposing them to predators/destruction.
- Manual collection and destruction of adult beetles during peak period of emergence to reduce grubs population but invariably emergence occurs atfer three to four pre-monsoon showers.
- Proper drainage reduces the population of root grubs as the grubs prefers moist soil.
- Removal of weeds and fallen leaves prevents the movement of grubs.
- Application of powdered neem cake @ 2kg/palm in the root zone induces the emergence of new roots.
- Entomopathogenic nematodes (EPN), *Steinernema carpocapsae* liquid suspension @1.5 billion infective juveniles /ha (approximately 1crore IJs/plant) during June July with commencement of monsoon and second application during September October along with insecticide, Imidacloprid 17.8 SL@0.0045% (0.5ml/2 liters of water/plant) drenching around the root zone. Imidacloprid is synergistic with EPNs and exhibits good compatibility in managing the root grubs.
- Providing irrigation regularly to maintain optimum soil moisture for better survival and establishment of nematodes during the period of treatment.
- Application of nutrients as per soil test based recommendations for improving the health of the palms.

References

Caroli, L., Glazer, I. and Gaugler, R. (1996). Entomopathogenic nematodes infectivity assay: comparison of penetration rate into different hosts. Biocontrol Sci. Techn. 6: 227-233.

Kaya, H.K. and Stock, S.P. (1997). Techniques in insect nematology. In: Lacey, L. A. (ed.), Manual of techniques in insect pathology, Academic Press, San Diego, CA. pp. 281-324.

Pervez, R., EAPEN, J. S., Devasahayam, S., & Jacob, T. K. (2016). Eco-friendly management of cardamom root grub (*Basilepta fulvicorne Jacoby*) through entomopathogenic nematodes.

Ravichandra, N. G. (2013). *Plant nematology*. IK International Pvt Ltd.

Walia, R. K., Walia, R. K., & Bajaj, H. K. (2003). *Textbook on Introductory Plant Namatology*. Director, Directorate of Information and Publications of Agriculture.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/21/0625

CONSERVATION AGRICULTURE AND SUSTAINABLE DEVELOPMENT GOALS

Abhishek Meena[1], Shruti Setia[1] and Shreyas Bagrecha[2*]

[1]M.Sc. Scholar, Agronomy Section, ICAR- National Dairy Research Institute, Karnal, Haryana (132001)
[2]Ph.D. Scholar, Agronomy Section, ICAR- National Dairy Research Institute, Karnal, Haryana (132001)
*Corresponding Email: shreyasbagrecha98@gmail.com

Abstract

The agricultural sector is India's largest employer, with a 54.6 per cent share in national employment. However, the current agricultural system is collapsing due to its dependence on exhausting factors becoming unfavourable for production amid climate change. Conservation Agriculture (CA) has emerged as a sustainable farming system that enhances factor-use efficiency and reduces resource degradation. Conservation agriculture will help achieve the sustainability development goals (SDGs) of the United Nations (UN). These SDGs are 17 global objectives released by the UN in 2016 to be addressed by 2030 to tackle interlinked global challenges like poverty eradication, clean resources, and life and health. Conservation agriculture advances several SDGs, particularly those aimed at reducing hunger and poverty, mitigating resource depletion, ensuring access to essential resources and addressing climate change. The impact of conservation agriculture on achieving SDGs cannot be underestimated.

Keywords: Sustainable, Resource use efficiency, Soil health, Food security, Biodiversity

Introduction

Conservation agriculture (CA) is a sustainable agricultural system characterized by four core principles: minimal soil disturbance, permanent soil cover, diversified cropping, and reduced traffic. These principles enhance resource-use efficiency and factor productivity by preserving the natural resources and promoting environmental sustainability. Adhering to these principles, CA offers an optimal alternative to intensive farming practices, thereby mitigating environmental degradation (Kassam *et al.*, 2022). The reliability of agricultural production systems depends on soil health and natural resources. Therefore, having fertile and productive land is essential for increasing yields, providing for human subsistence needs, and laying the groundwork for achieving the Sustainable Development Goals (SDGs). Rising issues such as poverty, hunger, climate change, and education prioritized under SDGs can be ameliorated by sustainable agricultural practices covered under CA. It can help mitigate climate change, a significant concern, by reducing pollution. Crop diversification in CA with the help of multiple cropping, both spatially and temporally, will help increase biodiversity, soil health, and on-farm resource management, ameliorating the negative effects of monoculture, such as pest resistance and nutrient exhaustion from soil, leading to unproductive land. The SDGs of Zero hunger, clean water and Sanitation, Responsible consumption and production, climate action, and life on land are all in line with and aided by CA practices. The core of CA's innovation is its integrated strategy for achieving agricultural sustainability and productivity. CA has the ability to significantly advance sustainable farming practices, address poverty and hunger, and mitigate the effects of climate change to help achieve the SDGs. By increasing farmers' income, wider SDGs will be indirectly satisfied. The potential of CA to create a more resilient and sustainable future is demonstrated in this study.

Sustainable Development Goals (SDGs)

Sustainable development has become a burning topic for the global community due to the increased imbalance of resources resulting from competition for growth and development. As this poses a threat to the very existence of human life on Earth, a path of action that would guarantee a secure environment for future generations has become necessary. The phrase "sustainable development" was created to ensure that progress is made in a way that preserves natural resources and allows them to be passed on to future generations undamaged. The goal of the 17 SDGs is to create a safer, more equitable, and prosperous world by 2030. It has framed 17 SDGs, as shown in Figure 1.

Figure 1: UN Sustainable Development Goals

Sustainable Development Goals and Conservation Agriculture

The objectives delineated herein provide a comprehensive framework for nations and stakeholders to collaborate in the pursuit of a more sustainable and equitable future for both humanity and the environment. The SDGs are to be achieved by 2030, with progress being systematically monitored and assessed to ensure that global efforts remain aligned with these targets. CA endorses several of the SDGs established by the United Nations, including a) SDG 2: Zero Hunger, b) SDG 6: Clean Water and Sanitation, c) SDG 12: Responsible Consumption and Production, d) SDG 13: Climate Action, and e) SDG 15: Life on Land. A detailed exposition of CA's support for these SDGs is provided below (Figure 2).

SDG 2: ZERO HUNGER

The SDG 2 seeks to eradicate hunger by promoting nutrition and food security. CA practices contribute to improved soil health and fertility, which in turn enhance water retention capacity and nutrient availability. Healthy soil fosters increased soil productivity, ultimately boosting crop yields. A robust edaphic environment enables farmers to cultivate more crops or produce more food from the same land area, addressing the demands of future agricultural practices. CA emphasizes resource-use efficiency and incorporates livestock components of Integrated Farming Systems (IFS) to reduce chemical usage, ensuring sustainable production over the long term. Soil conservation efforts mitigate land degradation, thereby increasing the availability and productivity of land; thus, CA serves as an effective management strategy for achieving SDG 2 (Jat *et al*., 2020). Furthermore, diversification, post-harvest management, and climate-resilient practices are essential for ensuring food security and achieving zero hunger.

SDG 6: CLEAN WATER AND SANITATION

CA mitigates soil erosion more effectively than traditional agricultural methods, thereby reducing sediment accumulation in water reservoirs and ensuring the provision of clean water for all. The enhancement of soil water-holding capacity and infiltration rates facilitates the recharge of groundwater and aquifers, thereby making water accessible to plants for evapotranspiration and metabolic functions. By integrating nutrient management and integrated pest management (IPM) practices, CA reduces the reliance on agrochemicals, consequently diminishing the production of chemicals by industry and preventing their discharge into aquatic ecosystems. This approach safeguards water quality and sanitation, promoting a comprehensive strategy for sanitation and watershed management. Wetlands possess the capacity to purify both soil and water. Conservation farming practices decrease soil runoff and augment the availability of water in the root zone, particularly in arid regions. Consequently, CA supports the overarching goal of SDG-6 by ensuring the provision of clean water resources for human populations, ecosystems, and agricultural activities.

SDG 12: RESPONSIBLE CONSUMPTION AND PRODUCTION

The foundation of CA is a sustainable system characterized by the efficient utilization of resources such as energy, water, and inputs. CA enhances nutrient and water efficiency through the promotion of soil health and improved water management practices. By employing an integrated approach, CA minimizes the necessity for chemical inputs and the energy required for their production. Techniques such as crop rotation, including the use of cover crops, mitigate pest pressure and reduce waste through effective post-harvest management. The reduction of waste and optimization of production result in a diminished environmental footprint. CA practices, including Integrated Nutrient Management (INM), (IPM), and agroforestry, foster environmentally friendly and resilient production systems with significant biodiversity, thereby contributing to sustainable production and consumption patterns.

SDG 13: CLIMATE ACTION

The global average greenhouse gas (GHG) emissions from agriculture account for 13.5% (IPCC, 2007), with India's contribution being 2.8%. The Global Warming Potential (GWP) can be mitigated through practices such as zero tillage and soil cover, which help maintain canopy temperatures 1-1.5°C lower and enhance moisture availability (Hobbs *et al*., 2008). Additionally, no-tillage practices contribute to increased carbon sequestration. Furthermore, residue retention, cover cropping, and waste management facilitate carbon sequestration and reduce CO_2 emissions. Consequently, CA

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

management practices, which reduce soil erosion and enhance water infiltration, mitigate the impacts of climate change on water availability. Crop diversification and improved soil conditions enhance plant resistance to lodging and abiotic stress, thereby promoting resilient farming systems. CA enables sustainable food production from small landholdings, eliminating the need for deforestation. Emphasizing carbon sequestration, agroforestry, sustainable crop production, and resilient production systems is essential in combating climate change.

SDG 15: LIFE ON LAND

The primary focus of this objective is the conservation of biodiversity, which entails promoting the sustainable utilization of terrestrial ecosystems through the enhancement of biodiversity. Practices such as crop rotation and the use of cover crops are instrumental in preventing soil degradation, including soil erosion, and in providing habitats for beneficial organisms, such as pollinators and insects. Healthy soil, characterized by a high content of soil organic carbon, facilitates nutrient cycling due to its robust recovery potential. The integration of shrubs and trees contributes to the creation of habitats for avian species and wildlife, thereby augmenting biodiversity. Furthermore, effective water management and the reduction of chemical usage are crucial in preventing the contamination of water bodies, thereby preserving aquatic biodiversity. In summary, CA enhances soil health, protects watersheds, reduces pesticide usage, and promotes biodiversity and sustainable land management practices, all of which are integral to achieving SDG-15. CA supports the long-term sustainability of the earth's biodiversity by balancing agricultural productivity with the preservation of terrestrial ecosystems.

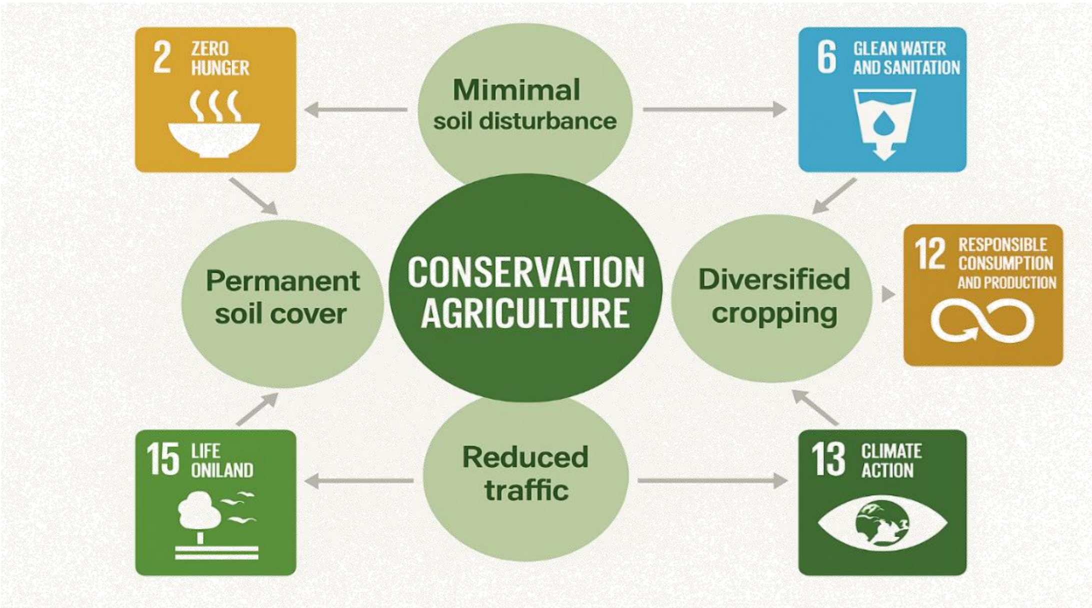


Figure 2: An illustration of the main SDGs connecting with conservation agriculture

INDIA SDG Index Status

The overall SDGs score for the country is 71 for the period 2023-24, marking a notable improvement from a score of 66 in 2020-21 and 57 in 2018, as reported in the Baseline report. Regarding SDG 2, there has been an enhancement in the composite score for Goal 2, transitioning from the Aspirant category in the SDG India Index 3 (2020-21) to the Performer category in the SDG India Index 4 (2023-24). For SDG 6, the score has significantly increased from 63 in 2018 to 89 in 2023-24. In terms of SDG 12, 91.5% of biomedical waste generated was treated in 2022, and 54.99% of hazardous waste was recycled or utilized out of the total hazardous waste generated in 2022-23, representing an increase from 44.89% in 2018-19. Concerning SDG 13, there has been an improvement in electricity generation from renewable energy sources, rising from 36.37% in 2020 to 43.28% in 2024. For SDG 15, the score increased from 66 in Index 3 (2020-21) to 75 in Index 4 (2023-24). The number of states and union territories in the front-runner category increased from 17 in 2020-21 to 32 in 2023-24. According to the India State of Forest Report 2021, approximately 25% of the geographical area is covered by forests and tree cover, with a 1.11% increase in carbon stock in forest cover (PIB, 2024).

Future recommendation

Governmental support or policy development should focus on providing financial subsidies or technical assistance to address the initial investment costs. It is essential to implement awareness projects targeting farmers, policymakers, and stakeholders, engaging them through workshops. Research should be conducted to develop region-specific conservation agriculture practices. Field demonstrations at Krishi Vigyan Kendras (KVKs) or by successful farmers can facilitate the dissemination of information to other farmers. The integration of Integrated Farming Systems (IFS) with conservation agriculture and public-private partnerships to pool resources should be expanded. Proper evaluation, monitoring, report generation, and the identification of gaps, along with methods to address them, are crucial. Future advancements in climate-smart agriculture, including resilient crop varieties and weather forecasting services, may significantly contribute to achieving the SDGs.

Conclusion

Conservation agriculture represents a significant approach for advancing the United Nations Sustainable Development Goals by incorporating the principles of minimal soil disturbance, permanent soil cover, crop diversification, and controlled traffic. This agricultural practice contributes to food security, climate action, water quality and sanitation, as well as sustainable production and consumption, by enhancing soil health, improving water management, and implementing climate-resilient production systems. It alleviates hunger by increasing the availability of nutrients and improving water quality. Furthermore, conservation practices enhance biodiversity and the quality of life on land. Addressing these challenges and leveraging the opportunities will be essential for expanding conservation agriculture and achieving a sustainable future for agriculture.

References

Hobbs P.R, Sayre K and Gupta R (2008). The role of conservation agriculture in sustainable agriculture Philosophical Transactions of the Royal Society B: Biological Sciences 363(1491): 543–555.

Jat M.L, Chakraborty D, Ladha J.K, Rana DS, Gathala M.K, McDonald A and Gerard B (2020). Conservation agriculture for sustainable intensification in South Asia Nature Sustainability 3(4): 336–343.

Kassam A, Friedrich T and Derpsch R (2022). Successful Experiences and Lessons from Conservation Agriculture Worldwide. Agronomy 12(4): 769.

PIB. (2024). Release of SDG India Index 2023 -24. Available via DIALOG. https://www.pib.gov.in/PressReleseDetailm.aspx?PRID=2082313&reg=3&lang=1

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/22/0625

READY TO EAT- FOXTAIL MILLET

N. Gobikashri[1*], S. Punithkumar[2] and C. Nivetha[3]

[1] Ph.D. Research Scholar, Department of Agronomy, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal - 609603, India
[2] PG Research Scholar, Department of Agronomy, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal - 609603, India
[3] Assistant Professor, Department of Agronomy, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal – 609603, India
*Corresponding Email: gobikashri08@gmail.com

IntroductionA healthy and balanced nutritive diet is the mantra to good health. In recent times, consumption of millets have a balanced nutritional diet leading to a healthy lifestyle among the people. In India, millets have been the traditional component of a food basket.

Millets is one of the oldest foods and it is consumed by more than 1/3rd of the world's population. These are one of the oldest foods known to humanity and plays a significant role in traditional diets in many region. In our country millets covers an area about of 9 lakh hectare and production of 42 lakh metric tonnes and productivity of 4421 kg/ha in 2020-2021. (Agriculture department policy note 2020-2021). Millets are nutri cereals comprising of sorghum, pearl millet, finger millet (major millets) foxtail, little, kodo, proso and barnyard millet (minor millets). Millet are small seeded coarse cereals, that belongs to the family *poaceae*.

Millets are highly nutritious, non glutinous and non acid forming foods. They serve as a good source of proteins, micronutrients and phytochemical. Millet contains 7-12% protein, 2-5% fat, 65-75% carbohydrates and 15-20% dietary fibre (FSSAI). Millet protein contains amino acids in balanced proportions and is rich in methionine, cystine and lysine. These are especially beneficial to vegetarians who depend on plant food for their protein nourishment

Foxtail millet

Foxtail millet (*Setaria italica* L.) belonged to Poaceae family and it is commonlyknown in India as vernacular name *viz*., Kangni (Hindi), Thenai (Tamil), Kang (Gujarati), Navane (Kannada) and Kaon dana (Bengali). In 100 g of foxtail millet grain contains excellent source of good fibre at 8 g, protein at 12.3 g, carbohydrates at 60.9 g, fat at 4.3 g, calcium at 31 mg, Iron at 2.8 mg, phosphorus at 290 mg, vitamins at 3.3 g, minerals at 3.3 g and food energy at 323-350 K Cal. Foxtail millet ranks 2nd in protein content. It consisting of 12.30g followed by proso millet contains 12.50g. Foxtail millet ranks 3rd place in calcium content. It consisting of 31mg followed by pearl millet 42mg and wheat 41mg. It is high fibrous content (Agriculture department policy note 2020-2021). Foxtail millet, cultivated in Tamil Nadu mainly in Salem, Cuddalore and Namakkal. The area of foxtail millet cultivation (Thenai) in Tamil Nadu is 0.007 lakh hectare and production is 0.003 lakh metric tonnes and productivity are 472 kg/ha.

Foxtail millet contains a pertinent number of nutritional components, especially starch, protein, vitamins, and minerals. It has double quantity of protein content compared to rice. It controls blood sugar and cholesterol. It increases disease resistant capacity when consumed and is considered ideal food for people suffering from diabetes and gastric problem. All these nutritional properties have made foxtail millet an important ingredient for preparing noodles, nourishing gruel or soup, brewing alcoholic beverages, cereal porridges and pancakes *etc..,* so, let's start eat the delicious and nutritional foxtail millet through different tasty recipes and value-added products and keep one's body strong and immune.

Value added products from foxtail millet:

- Foxtail Millet Flour
- Foxtail Millet Puffs
- Foxtail Millet Bread
- Foxtail Millet Vermicelli
- Foxtail Millet Pasta
- Foxtail Millet Cookies
- Foxtail Millet Cake
- Foxtail Millet Flakes
- Foxtail Millet Nutri Bar

Foxtail Millet Flour Preparation method

Foxtail Millet → Cleaning → Hammer mill → Cooling → Flour → Packaging

- Flour is used as a main ingredient for various recipes. Foxtail Millet grains are processed by dry milling.
- The dry milling process starts with the cleaning of grains.
- The cleaned grain is milled by the hammer mills to separate the endosperm, germ and bran from each other to get fine flour.

It is used to make rotis and bakery foods (cakes and biscuits).

Foxtail Millet Puff Preparation method

Foxtail Millet Grain → Grading → Dehulling → Dehulled grain → Conditioning → Water → Gun puffing → Foxtail puffs

- Foxtail puffs are product which is a resultant of explosive puffing or gun puffing where the foxtail grain is expanded to maximum expansion consistent with the grain identity (similar shape of the grain).
- It is the RTE (ready to eat) snack which is developed using puff gun machine.
- The puff gun machine is loaded with dehulled foxtail grain onto a rotating barrel and the mixture is roasted for and fired resulting in a puffed foxtail millet product.

- The foxtail puffs are white in colour and are crispy in nature, similar to the puffed rice.
- The shelf life is for 2 months when packed in air tight MET pouches at ambient temperatures and study is still in progress. They are rich in protein and fibre.

Foxtail Millet Bread Preparation method

Millets Bread /Bun → Foxtail millet and Wheat flour → Add Yeast, Free Fat, Salt and Sugar → Dough Kneading → Panning → Proofing → Knock Backing → Shaping → Baking → Depanning → Cooling → Slicing → Packaging

- Bread is a RTE product which is prepared by mixing a mixture of flour, water, fat, salt and yeast until the mixture gets converted into dough, which is followed by baking the dough into a loaf.
- Millet breads have been prepared at IIMR of replacing 50% wheat in bread with foxtail millet flour of varied proportions and adding superior quality yeast, trans-free fat, salt and sugar.
- The dough is proofed and then baked in oven to get bread. Round balls of the dough is made and baked to get bun
- It has a shelf life of 6 days when packed in LDPE packets.

Foxtail Millet Vermicelli

Preparation method

Foxtail, Wheat Semolina → Weighing → Sieving → Mixing add water → Extrusion and Cutting → Drying → Cooling → Packaging

- Vermicelli is prepared using cold extrusion
- Foxtail millet semolina and refined wheat semolina are blended in the mixing compartment of the vermicelli-making machine and blended with water for 30 minutes and extruded using a round die.
- The vermicelli is allowed to temper in room temperature for 8 hours and then dry in a cabinet drier for 6 hours.
- Used to make semiya (sweet/spicy) and can be added to milk.
- Foxtail millet vermicelli can be stored for six months at ambient temperature

Foxtail Millet Pasta Preparation method

Foxtail, Wheat Semolina → Weighing → Sieving → Mixing → Add water → Extrusion and Cutting → Drying → Cooling → Packaging

- Foxtail millet semolina and refined wheat semolina are blended in the mixing compartment of the vermicelli-making machine and blended with water for 30 minutes and extruded using a pasta die.
- Wheat is added as the less gluten content of millets requires minimum percentage of wheat for preparing pasta
- The machine is fitted with dies of different sized perforations (or) shape/size of pasta products, respectively
- The cold-extruded products are normally steamed for a few minutes to stabilize the pasta and then dried.
- It can be stored for three months at ambient temperature.

Foxtail Millet Cookies Preparation method

Flour (Foxtail: Wheat) → Sugar, Milk Solids, Salt Flavouring → Planetary Mixer → Automatic Cookie Machine Collection of Cookies → Rotary Oven → Cooling → Packaging

- Cookies are popular ready-to-eat product consumed by different age groups in a family and it is prepared using a planetary mixer, automatic cookie making machine and rotary oven.
- Cookies have been prepared by foxtail millet flour of superior quality with addition of sugar, milk solids, trans free-fat, salt and nature identical flavoring substances
- It has a shelf life of 6 months.

Foxtail Millet Cake Preparation method

Add fat, sugar and eggs → Whisk till creamy consistency → Add Foxtail millet flour → Add chocolate/vanilla essence → Put in baking mould lined with parchment paper → Bake in oven at 180 Degree Centigrade for 25 min → Cool and Pack

- Cake is a RTE product which is prepared by mixing a mixture of flour, sugar, fat, eggs and flavoring ingredients until the mixture gets converted into dough, which is followed by baking the dough. Millet cakes have been prepared using 100% foxtail millet flour and adding superior quality fat, sugar, eggs and chocolate/vanilla essence and also adding all the millets together with varied proportions.
- It has a shelf life of 4 days when packed in MET packets.

Foxtail Millet Flakes Preparation method

Raw material → conditioning → Water → roasting the grains → Roller flaker machine → Extruded flakes → Drying at 50ºC → Packaging

- Raw materials were soaked with water separately. Draining the water and roasting it. The moisture of raw material mixture was adjusted to 10-15 %.the grains were put into flaking machine
- In this process, the material comes into contact with the hot surface of the roaster and heat is transferred to the core of the grain. The process is continued until the grains get cooked or the starch content is gelatinized. During this time, the moisture content drops to about 20%.
- The flattened foxtail millet or the flakes of desired thickness are collected manually.
- The duration of flattening depends on the kind of flakes to be produced, i.e. thin or thick flakes.
- The flaked material will be fairly circular in shape but generally fissured at the edges, and it is screened over perforated decks to separate out finer broken.
- The thickness of the flakes will be in the order of <1 mm. The flakes are further dried by spreading in an open place or using a mechanical dryer, and then packed.

Foxtail Millet Nutri Bars Preparation method

Weighing foxtail millet grain and Broken Flakes → mixing → Add Binder and Sweetener (Honey Syrup) → Shaping → Cooling → Packaging

- Blending the flakes/popped grains and foxtail millet and dry roasted nuts.
- Then these blends are pulverized and mixed with honey syrup and it mixing and shaping cutting and packed with aluminum foil.

Conclusion

Above we can see many value added products and different delicious recipes to increase commercial value in foxtail millet. It provides income generation and improve livelihood to cultivating farmers and rural people. Through any missions or welfare programs, potential entrepreneurs learn about millets processing, value addition and commercialization. Today itself let's start to eat nutritional foxtail millet in daily diet. Can we start together?.

Reference

Dayakar Rao B, Sangappa, Vishala A.D, Arlene Christina G.D and Tonapi V.A. 2016. Technologies of Millet Value Added Products. Centre of Excellence on Sorghum, *ICAR-Indian institute of Millets Research*. Rajendranagar, Hyderabad, India. Pg. 48.

Dayakar Rao B, Vishala AD, Arlene Christina GD, Tonapi VA, 2016 Millet Recipes, A Healthy Choice, *ICAR- Indian Institute of Millets Research*, Rajendranagar, Hyderabad. Pg.138.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 05/VI/23/0625

GMOS VS GENE EDITING: A CLEAR DIVIDE IN MODERN CROP BIOTECHNOLOGY

Purva Khandelwal

Ph.D. Scholar, College of Post Graduate Studies in Agricultural Sciences,
Central Agricultural University (Imphal), Umiam-793103, Meghalaya, India
*Corresponding Email: khandelwalpurv@gmail.com

Abstract

The debate over genetically modified organisms (GMOs) and gene-edited crops is heating up as new biotechnologies transform agriculture. While GM crops involve inserting foreign DNA, gene editing (e.g., CRISPR) allows precise changes without transgenic modifications. This article explores the scientific distinctions, regulatory approaches, and public perceptions shaping the future of food production.

Keywords : Gene Editing, GMO Crops, CRISPR, Agricultural Biotechnology, India Genome-Edited Rice

Introduction

In recent years, the world of agriculture has been buzzing with terms like GMO and gene editing—but what do they mean, and why should farmers, consumers, and policymakers care? For thousands of years, humans have used traditional modification methods like selective breeding and cross-breeding to cultivate plants and animals with more desirable traits. Most of the foods we eat today were created through these methods, from corn with a range of colors, sizes, and uses, to strawberries and diverse varieties of mango. However, traditional breeding can take a long time, and making highly specific changes is often challenging. In the early 1970s, scientists Herbert Boyer and Stanley Cohen achieved a groundbreaking feat—they developed recombinant DNA technology, allowing them to cut DNA from one organism and insert it into another. This technique is widely considered the birth of genetic engineering. Building on these breakthroughs, the process of genetic engineering was refined into a series of precise steps. Scientists identify the specific gene responsible for a desired trait, whether it's in a plant, animal, or microbe, carefully isolate and copy it, and then insert it into the DNA of a target organism. The modified organism is then grown and tested to ensure it expresses the new trait effectively. This method allowed traits like pest resistance or improved nutrition to be introduced into crops in ways that traditional breeding could never achieve. Today, however, the conversation is evolving. With the advent of gene editing technologies like CRISPR, which can make precise edits to a plant's DNA without introducing foreign genes, the line between GMOs and gene-edited crops is being hotly debated. While both involve changing a plant’s genetic makeup, they differ significantly in technique, regulation, and public acceptance. This article unpacks the key distinctions between GMOs and gene-edited crops, examining their underlying technologies, regulatory frameworks in India, and the public concerns they raise. As gene editing emerges as a promising tool in modern agriculture, it is increasingly being recognized not just as an extension of genetic modification but as a transformative approach with its own scientific, regulatory, and ethical dimensions. The article also highlights India’s recent milestone in this field with the release of its first genome-edited rice varieties, marking a significant step forward in agricultural innovation. Understanding these developments is essential to shaping policies and innovations that can sustainably meet the challenges of food security in a changing world.

GMOs and Gene Editing: Two Paths to Crop Innovation

The two major approaches—genetic modification (GMO) and gene editing- share the goal of enhancing crops, but their methods and outcomes differ in important ways. GMOs are created by introducing DNA from an entirely different species into a plant's genome. For example, a gene from a soil bacterium might be inserted into a corn plant to make it resistant to insect pests. This process, known as recombinant DNA technology, was first developed in the 1970s (Cohen *et al*., 2021) and led to the commercialization of the Flavr Savr tomato in 1994 (Bruening & Lyons, 2000). Since then, GM crops like herbicide-tolerant soybeans and insect-resistant cotton (Bt cotton) have become common in global agriculture (ISAAA, 2021). While these crops have provided benefits such as reducing pesticide use and boosting yields (Brookes & Barfoot, 2023), the method of inserting foreign DNA has sparked public debate. Issues around food safety, environmental risks like gene flow to wild relatives, and concerns about corporate seed control have made GMOs a global flashpoint. The major concerns are related to potential environmental and health risks, but there are also fears about adverse social implications, such as IPRs, GM technology, and privatized research could undermine traditional knowledge, seed sovereignty, and smallholder farmers (Qaim, 2009).

In recent years, however, advances in biotechnology have introduced a new generation of tools that aim to overcome some of these concerns—gene editing technologies. Unlike traditional GMOs, gene editing offers a more precise and potentially less controversial approach to improving crops by making targeted changes within the plant's DNA.

Gene editing tools—such as CRISPR-Cas9, TALENs, and ZFNs—allow scientists to make highly precise, targeted changes to an organism's existing DNA, often without introducing genes from other species (Doudna & Charpentier, 2014). This can involve switching off unwanted genes, tweaking existing ones, or mimicking natural mutations that could take years—or decades—to achieve through conventional breeding methods. Gene-edited crops have already made headlines, including mushrooms that resist browning and wheat with lower gluten content (Waltz, 2016). Since these crops often do not contain foreign DNA, many scientists and some regulators argue they are closer to traditional breeding and may pose fewer environmental or food safety concerns (Ishii & Araki, 2016). However, critics point out that gene editing is still a form of genetic manipulation, raising ethical, ecological, and governance questions (Eckerstorfer *et al*., 2019).

Concerns and Regulation: India's Approach to GMOs and Gene-Edited Crops

Despite their potential to improve yield, resilience, and nutritional content, genetically modified (GM) and gene-edited crops continue to raise concerns globally, and India is no exception. For GMOs, the primary apprehensions revolve around food safety, ecological impact, and socioeconomic consequences. Environmentalists and civil society groups worry about the long-term effects of GM crops on biodiversity, gene flow to native species, and the development of pest or herbicide resistance (Shiva, 2016). Additionally, the concentration of seed patents in the hands of a few multinational corporations has raised red flags about farmer autonomy and seed sovereignty, especially in developing countries like India (Qaim, 2009).

When it comes to gene-edited crops, although the technology is more precise and doesn't always involve the transfer of foreign DNA, similar concerns exist. Critics argue that off-target effects, unintended changes in the genome, could still pose risks to human health or the environment. Others question the transparency of how these technologies are tested and regulated, especially in the absence of long-term safety data (Eckerstorfer *et al*., 2019).

India's Evolving Regulatory Landscape

While genetically modified (GM) and gene-edited crops promise solutions to some of agriculture's toughest challenges—like pests, climate stress, and yield stagnation—they've also triggered debates across scientific, environmental, and public domains. Concerns about food safety, impact on biodiversity, and corporate control of seeds have made some stakeholders wary. For GMOs, especially, which often involve inserting genes from unrelated species, critics fear unintended consequences for health and the environment, along with threats to traditional farming knowledge and smallholder independence (Qaim, 2009; Shiva, 2016). To address these concerns, India put a formal regulatory system in place early on. Under the Environment Protection Act of 1986, India created the Genetic Engineering Appraisal Committee (GEAC) to oversee the approval and regulation of genetically modified organisms. This led to Bt cotton becoming the only GM crop approved for commercial cultivation in the country so far. Other crops like GM mustard and Bt brinjal have remained stuck in policy debates and public opposition. However, the rise of gene editing technologies, like CRISPR, has brought a shift in regulatory thinking. These techniques allow scientists to make highly specific changes within a plant's own genome, often without introducing foreign DNA. As a result, many scientists argue that gene-edited plants are more like conventionally bred plants than traditional GMOs.

Recognizing this, India's Ministry of Environment, Forest and Climate Change (MoEFCC) made a landmark announcement on March 30, 2022. It declared that gene-edited plants developed through SDN-1 and SDN-2 techniques, provided they don't carry foreign genes, will no longer be classified as GMOs and will be exempt from the lengthy biosafety assessment typically required under GMO regulations. The Ministry later released detailed safety guidelines on May 17, 2022, outlining the process for the responsible and sustainable release of such genome-edited crops (Dionglay, 2024). This move marks a significant turning point in India's biotechnology regulation, aiming to encourage innovation while maintaining public and environmental safety. Experts see this as a balanced approach that could fast-track the development of improved crops, such as drought-tolerant rice or disease-resistant wheat.

India Leads the Way with New Gene-Edited Rice Varieties

In a historic move for Indian agriculture, two new rice varieties developed using gene-editing technology were officially released on May 4, 2025. DRR Rice 100 (Kamala) and Pusa DST Rice 1 are the first gene-edited rice varieties in the world to be approved for cultivation. The launch was celebrated in New Delhi, led by Union Agriculture Minister Shri Shivraj Singh Chouhan. These rice varieties were developed by scientists from the Indian Council of Agricultural Research (ICAR) using a powerful gene editing tool- CRISPR, which allows scientists to make precise improvements in a plant's DNA, without adding genes from other species (ICAR, 2025). These varieties represent a leap forward for Indian agriculture:

- DRR Rice 100 (Kamala) is designed to grow well even under tough conditions like drought and salty soil. It can produce 19% more yield, uses less water, and even reduces harmful greenhouse gas emissions.
- Pusa DST Rice 1 performs better in salty and alkaline soils, with yield increases of up to 30% in those conditions. This could help boost rice production in difficult farming areas.

This achievement marks a proud moment for India’s scientific community. It also shows how modern technologies can help farmers grow more with fewer resources, even as climate challenges grow. This breakthrough comes after the Indian government made changes to its rules in 2022 to allow gene-edited plants without foreign DNA to be regulated differently from traditional GMOs. Thanks to these changes, scientists and farmers now have clearer, faster pathways to bring useful innovations to the field. India’s step forward in gene-edited rice is not just about science, it’s about feeding the future, supporting farmers, and using home-grown innovation to tackle global challenges.

Conclusion

As biotechnology advances, understanding the distinction between GMOs and gene-edited crops becomes crucial for shaping the future of farming and food security. While GMOs involve the transfer of foreign genes and have long been subject to public scrutiny and tight regulation, gene editing offers a more precise, potentially safer alternative that often mimics natural processes. India’s progressive regulatory approach—especially the exemption of certain gene-edited crops from GMO rules—reflects a shift toward encouraging innovation while safeguarding public and environmental health. The release of the world’s first gene-edited rice varieties marks not just a scientific milestone, but a step toward more resilient, resource-efficient agriculture. With careful oversight, transparent communication, and continued research, these technologies can empower farmers, benefit consumers, and help meet the challenges of a changing climate and growing population.

References

Brookes, G., & Barfoot, P. (2023). *GM Crops: Global socio-economic and environmental impacts*. GM Crops & Food.

Bruening, G., & Lyons, J. M. (2000). The case of the FLAVR SAVR tomato. *California Agriculture*, *54*(4), 6–7. https://doi.org/10.3733/ca.v054n04p6

Cohen, S. N., Chang, A. C. Y., Boyer, H. W., & Helling, R. B. (2021). Construction of biologically functional bacterial plasmids in vitro. In *The Ethics of Biotechnology* (pp. 225–230). Routledge.

Dionglay, C. (2024, January 24). Updates on Global Regulatory Landscape for Gene-Edited Crops. *ISAAA. Inc*. https://www.isaaa.org/blog/entry/default.asp?BlogDate=1/24/2024#:~:text=India's%20Ministry%20of%20Environment%2C%20Forest,release%20of%20genome%2Dedited%20plants.

Doudna, J. A., & Charpentier, E. (2014). Genome editing. The new frontier of genome engineering with CRISPR-Cas9. *Science (New York, N.Y.)*, *346*(6213), 1258096. https://doi.org/10.1126/science.1258096

Eckerstorfer, M. F., Dolezel, M., Heissenberger, A., Miklau, M., Reichenbecher, W., Steinbrecher, R. A., & Waßmann, F. (2019). Corrigendum: An EU perspective on biosafety considerations for plants developed by genome editing and other new genetic modification techniques (nGMs). *Frontiers in Bioengineering and Biotechnology*, *7*, 90. https://doi.org/10.3389/fbioe.2019.00090

ICAR. (2025, April 4). *Union Agriculture Minister Shri Shivraj Singh Chouhan Announces Two Genome-Edited Rice Varieties Developed in India*. Indian Council of Agricultural Research. https://icar.org.in/union-agriculture-minister-shri-shivraj-singh-chouhan-announces-two-genome-edited-rice-varieties

ISAAA. (2021). *Breaking Barriers with Breeding: A Primer on New Breeding Innovations for Food Security* (Brief No. 56). ISAAA. https://www.isaaa.org/resources/publications/briefs/56/default.asp

Ishii, T., & Araki, M. (2016). Consumer acceptance of food crops developed by genome editing. *Plant Cell Reports*, *35*(7), 1507–1518. https://doi.org/10.1007/s00299-016-1974-2

Qaim, M. (2009). The economics of genetically modified crops. *Annual Review of Resource Economics*, *1*(1), 665–694. https://doi.org/10.1146/annurev.resource.050708.144203

Shiva, V. (2016). *Who really feeds the world?: The failures of agribusiness and the promise of agroecology*. North Atlantic Books.

Waltz, E. (2016). Gene-edited CRISPR mushroom escapes US regulation. *Nature*, *532*(7599), 293. https://doi.org/10.1038/nature.2016.19754.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/24/0625

MAJOR SOURCES OF HEAVY METAL CONTAMINATION

Jitesh Singh[1*], Seerat Thind[1], Amrit Sadhana[2] and Md Meraj[3]

[1]M.F.Sc Scholar, Department of Aquaculture, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab (141004), India
[2]M.F.Sc Scholar, Department of Fisheries Resource Management,
Dr. Rajendra Prasad Central Agriculture University, Samastipur, Bihar (848125), India
[3]M.F.Sc Scholar, Department of Aquaculture,
Dr. Rajendra Prasad Central Agriculture University,
Samastipur, Bihar (848125), India
[*]Corresponding Email: Singhjitesh302@gmail.com

Abstract

A large quantity of harmful by-products from human activities is consistently present across various environments, contributing to pollution and ecological disruption (Shalu *et al.*, 2025). Among these, heavy metal contamination in soil and water poses significant environmental and public health challenges globally. This article explores the major sources of heavy metal contamination, including both natural processes and anthropogenic activities. It discusses the pathways through which heavy metals enter the environment and presents case studies highlighting the extent of contamination.

Keywords: Anthropogenic activities, Environmental pollution, Heavy-metal contamination

Introduction

Aquaculture is rapidly emerging as one of the most dynamic sectors in global food production, serving as a vital source of fish and shellfish protein to meet increasing consumer demand (Vishal & Shalu, 2024a). Central to this industry is the role of feed, which provides essential nutrients for fish growth and energy metabolism. Inadequate nutrition can compromise the health of cultured species, leading to poor growth performance, heightened mortality rates, and increased susceptibility to diseases (Vishal & Shalu, 2025). The escalating demand for high-quality aquafeeds has driven greater dependence on wild-sourced fishmeal and fish oil (Vishal & Shalu, 2024b). Those may carry heavy metal contamination from the ocean. Moreover, pollution in aquatic ecosystems has become a critical global issue (Dubey *et al.*, 2024). The contaminants such as heavy metals infiltrating marine food sources. These pollutants not only threaten the health of aquatic species but also pose risks of bioaccumulation, leading to potential ecological disruptions and food safety hazards. Among feed components, chitin—extracted from crustacean exoskeletons and insect shells—serves as a valuable additive, enhancing fish growth and immune function in aquaculture (Suryawanshi *et al.*, 2024). However, the sources of chitin are often exposed to marine pollution, increasing the likelihood of heavy metal contamination. Such contaminants can enter aquafeeds, further elevating concerns regarding bioaccumulation and ecological sustainability. Heavy metals can infiltrate aquaculture systems both through environmental exposure and contaminated feed ingredients, underscoring the need for rigorous monitoring and sustainable feed management practices. Heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), and chromium (Cr) are naturally occurring elements with high atomic weights and densities. While some of these metals are essential in trace amounts for biological functions, elevated concentrations can be toxic to living organisms. The pervasive presence of these metals in the environment stems from both natural processes and anthropogenic activities, including industrial operations, agriculture, mining, and improper waste disposal. These activities have led to the accumulation of harmful heavy metals in ecosystems, creating significant risks to both human health and the environment.

However, anthropogenic activities have significantly amplified heavy metal concentrations in the environment. Industrial operations, such as mining and smelting, are primary contributors. A study by Nriagu and Pacyna (1988) quantified the global contamination of air, water, and soils by trace metals, highlighting the substantial impact of human activities. Mining activities, in particular, have been linked to severe environmental degradation. In the Peruvian Andes, communities near the Antamina mine have reported water scarcity and contamination due to mining operations. Similarly, in Brazil, the Xikrin Indigenous people have been affected by heavy metal contamination from Vale's nickel mining activities, leading to legal actions against the company.

Natural Sources of Heavy Metal Contamination

- ✓ **Geological Weathering**: The breakdown of rocks and minerals releases metals like arsenic, lead, and mercury into soils and water bodies. This process is a significant natural contributor to heavy metal presence in the environment (Garrett, 2000).
- ✓ **Volcanic Activity**: Eruptions emit metals such as mercury and arsenic into the atmosphere, which can deposit onto land and water surfaces, leading to contamination (Rytuba, 2002).
- ✓ **Forest Fires**: Combustion of vegetation can release stored heavy metals into the environment, contributing to atmospheric deposition and subsequent contamination of soil and water (Garrett, 2000).

Anthropogenic Sources of Heavy Metal Contamination

Human activities have significantly increased the concentrations of heavy metals in various environmental compartments. The major anthropogenic sources include:

Industrial Activities

Industries such as mining, smelting, electroplating, and manufacturing are primary contributors to heavy metal pollution. These operations release substantial quantities of metals into the environment through emissions, effluents, and waste disposal. For instance, mining activities can lead to the leaching of metals like arsenic and lead into surrounding soils and water bodies. Industrial effluents often contain high levels of metals such as chromium, cadmium, and nickel, which can contaminate water bodies if not properly treated (Alsafran *et al*., 2022; Nriagu & Pacyna, 1988).

Agricultural Practices

The use of fertilizers, pesticides, and sewage sludge in agriculture introduces heavy metals into the soil. Phosphate fertilizers often contain cadmium as an impurity, while certain pesticides include metals like copper and arsenic. Over time, these practices lead to the accumulation of metals in agricultural lands, affecting soil health and crop safety. Additionally, irrigation with contaminated water can further exacerbate soil contamination (Zhang *et al*., 2023).

Waste Management and Urbanization

Improper disposal of industrial and municipal waste, including electronic waste and batteries, contributes to heavy metal contamination. Landfills and waste dumps can leach metals into the soil and groundwater. Urban runoff carries metals from roads and buildings into water bodies. Furthermore, the corrosion of aging water supply infrastructure can release metals like lead into drinking water systems (Kumar & Bano, 2021; Shi *et al*., 2011).

Atmospheric Deposition

Combustion of fossil fuels, waste incineration, and industrial emissions release metals into the atmosphere. These airborne particles can settle onto land and water surfaces, leading to widespread environmental contamination. Motor vehicle emissions are a major source of airborne contaminants including arsenic, cadmium, cobalt, nickel, lead, and zinc (Alsafran *et al*., 2022).

Pathways of Contamination

Heavy metals can enter the environment through various pathways-

- **Air**: Emissions from industrial processes and combustion can release metals into the atmosphere, which later deposit onto land and water through precipitation.
- **Water**: Discharge of industrial effluents, agricultural runoff, and leachate from waste dumps can introduce metals into surface and groundwater.
- **Soil**: Deposition from air and water sources, as well as direct application of contaminated materials, can lead to soil contamination.

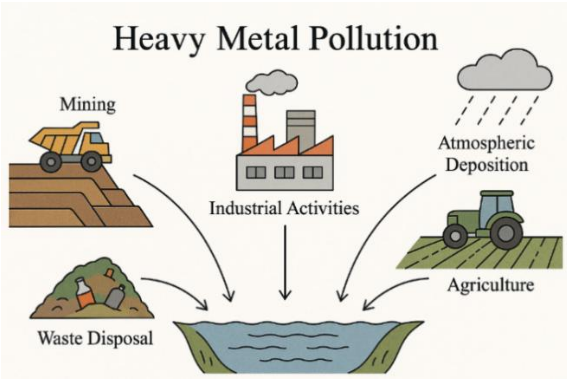


Fig-1: Diagram of Major Sources of Heavy Metal Pollution

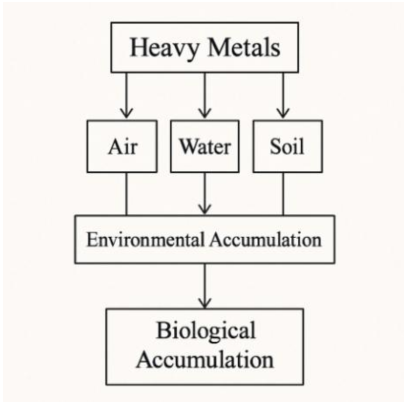


Fig-2: Distribution Pathways of Heavy Metals

Case Studies

Global Cropland Contamination

A recent study published by researchers from the American Association for the Advancement of Science reveals that up to 17% of the world's croplands may be contaminated with toxic heavy metals such as arsenic, cadmium, cobalt, chromium, copper, nickel, and lead. After analyzing nearly 800,000 global soil samples with machine learning techniques, the study highlights significant contamination particularly in South and East Asia, the Middle East, and parts of Africa. These pollutants pose health and ecological dangers to approximately 1.4 billion people. The contamination is largely attributed to industrial activities, including mining and possibly the demand for critical metals driven by the clean energy transition (e.g., wind turbines and EV batteries).

Fig-3: Map of Closed Metal Mines in Wales and Shropshire

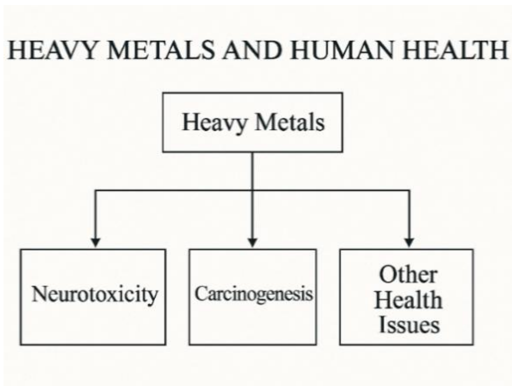


Fig-4: Mechanism of Heavy Metal Toxicity in Humans

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Legacy Pollution in Wales

Communities in Wales are facing health risks due to historical metal mining pollution, with over 1,300 abandoned sites leaking harmful metals like lead, zinc, and cadmium into the environment annually. These pollutants accumulate in the soil and water, affecting agricultural and domestic food production. Despite this, many residents are unaware of the dangers due to lack of regulatory standards and public information. Investigations revealed elevated and toxic concentrations of lead in farm produce, posing significant risks, especially to children. The Welsh government acknowledges the issue and is working with agencies to find solutions, but the absence of clear guidelines and biomonitoring programs remains a challenge.

Conclusion

Heavy metal contamination in soil and water is a multifaceted issue requiring integrated approaches for prevention and remediation. Combining regulatory measures, sustainable agricultural practices, and innovative remediation technologies is essential to mitigate the risks posed by heavy metals and protect environmental and public health. Continuous monitoring, public awareness, and international cooperation are crucial in addressing this global challenge.

References

Alsafran, M., Saleem, M. H., Aljabri, H., & Usman, K. (2022). Principles and Applicability of Integrated Remediation Strategies for Heavy Metal Removal/Recovery from Contaminated Environments. *Journal of Plant Growth Regulation*.

Dubey, S., Honnananda, B. R., Tyagi, A., Vishal, And Jagpal. (2024). Occurrence And Effect of Microplastic in Marine Environment. International Journal of Progressive Research In Engineering Management and Science, 4(3), 907-911.

Garrett, R. G. (2000). Natural Sources of Metals to the Environment. *Geochemistry: Exploration, Environment, Analysis*, 1(1), 1–10.

Kumar, A., & Bano, S. (2021). Effect of urbanization on heavy metal contamination: a study on Kannur district, Kerala, India. *Bulletin of the National Research Centre*, 45(1), 1–9.

Nriagu, J. O. (1989). A global assessment of natural sources of atmospheric trace metals. *Nature*, 338(6210), 47–49.

Nriagu, J. O., & Pacyna, J. M. (1988). Quantitative assessment of worldwide contamination of air, water and soils by trace metals. *Nature*, 333(6169), 134–139.

Nriagu, J. O., & Pacyna, J. M. (1988). Quantitative assessment of worldwide contamination of air, water and soils by trace metals. *Nature*, 333(6169), 134–139.

Rytuba, J. J. (2002). Mercury from mineral deposits and potential environmental impact. *Environmental Geology*, 43(3), 326–338.

Shalu, Shivkumar, Dubey, S., and Vishal**.** (2025). Recirculatory aquaculture systems (RAS). In S. S. Chinchorkar, P. Sial, S. C. Koujalagi, A. Prakash, I. Singh, and N. Kaur (Eds.), *Future perspectives in agriculture and allied disciplines* (1st ed., pp. 386–403). The Pustakalaya.

Shi, G., Chen, Z., Xu, S., Zhang, J., Wang, L., Bi, C., & Teng, J. (2011). Potentially toxic metal contamination of urban soils and roadside dust in Shanghai, China. *Environmental Pollution*, 156(2), 251–260.

Suryawanshi, U., Vishal, And Shalu. (2024). Overview Of Industrial and Economical Uses of Chitin and Chitosan. *Agriculture And Food: E-Newsletter*, 6(11), 243-247.

Vishal And Shalu. (2024). Antinutritional Factors and Digestibility Challenges in Aquafeeds: A Review. *International Journal of Progressive Research in Engineering Management and Science*, 4(10), 924-928.

Vishal and Shalu. (2024). Role of probiotics and prebiotics in aquaculture nutrition: A review. *International Journal of Research Publication and Reviews*, 5(11), 1833-1838.

Vishal and Shalu. (2025). Impact of bio-enrichment on larval survival and growth performance. *Agri-India TODAY*, 5(5), 47-53.

Zhang, H., Wang, Z., Wang, H., & Wang, X. (2023). Heavy Metal Contamination in Agricultural Soil. *Agronomy*, 13(6), 1521.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/25/0625

THE BEE WHISPERER: A CENTURY DEVOTED TO SWEETNESS

Rakesh Yonzone[1] and Maimom Soniya Devi[2]

[1]Assistant Professor, College of Agriculture (Extended Campus),
Uttar Banga Krishi Viswavidyalaya, Majhian, West Bengal, 733133
[2]Assistant Professor, College of Horticulture,
Central Agricultural University (Imphal), Bermiok, Sikkim, 737134

"He never learned from books, but from the gentle hum of bees and in their buzz, he found a lifelong melody of love, patience, and purpose".

In the quiet hills of Rungli Rungliot a small fog kissed village tucked away in the heart of Darjeeling time seems to move at its own gentle pace. Surrounded by emerald tea gardens, towering pine trees and the endless song of birds this place holds a secret not just of nature's beauty but of a man whose life has been a living poem.

That man is Mr. Rajman Moktan**,** now 100 years old and known lovingly as the *"Bee Whisperer."* While the world around him changed, kings left, empires fell, machines took over farms one thing remained constant: Rajman's unbreakable bond with honey bees.

A Humble Beginning with a Buzzing Heart

Born during the British colonial era in a time when his village had no electricity, no roads and no schools Rajman came into the world wrapped in simplicity. His family had little a thatched roof over their heads, a few cattle and a patch of land. But what they did had in abundance was love for the land and respect for nature.

As a young boy Rajman would follow the sound of bees echoing through the hills. While other children played in the fields he would crouch near wild hives, eyes wide, silently watching as bees worked in perfect harmony. He had no books or teachers but he listened to the bees as though they were speaking to him and perhaps in a way, they were.

"*They became my first teachers*," he says now, his voice soft and full of memory.
"*I didn't learn from people. I learned from them*."

The Making of a Master

As he grew older, Rajman began to gently collect honey from wild hives never harming the bees, always thanking them after. With time he started crafting traditional wooden and bamboo hives and placed them near flowering plants beside his house and field guided only by instinct and observation.

He stayed close to the bees, gently handling them with care. "*They can sense fear*," he says softly, "*but they also understand love"*.

Rajman's approach was deeply respectful. He never used chemicals or pesticides even when they became common. He believed bees deserved to live in a pure, clean world just as they had in the forests he first found them in.

Over the years, his small bee farm became a sacred space. Locals came not just for honey but for stories, advice and comfort. His honey was golden and thick said to heal sore throats, wounds, and even sadness. Each bottle carried a part of his soul.

A Century with the Bees

Now, a century later Rajman is a living legend. His back is slightly bent and his steps are slower, but the light in his eyes is still bright. Every morning, with the help of his cane he walks out to say hi to few left over hives the same way he has done for almost 90 years.

He speaks to his bees, sometimes humming softly sometimes just whispering their names. "*They are my daughters*," he says with a smile and "*Each one of them has a story*."

No at this stage he doesn't keep bees for earnings. He does it out of love the love that has lasted longer than most lifetimes. When visitors arrive they often find him in small kitchen garden near his hives, sharing tales from the past of how bees saved his life, gave him purpose and became his truest friends.

Pic 1: Each hive he touched holds the images of a lifetime care, fading memories and a devotion so quiet, yet so deep, it speaks through every drop of honey.

A Life That Speaks Without Words

Mr. Moktan never went to school. He never travelled far. He doesn't own a phone nor understands the internet. But his wisdom is deeper than many who hold degrees. In his silence, there's a language a way of being that teaches more than lectures ever could.

He teaches patience - the way bees build slowly, one cell at a time.
He teaches trust - how the hive depends on every member.
He teaches kindness - how nature rewards those who protect her.

Young people from nearby villages now come to learn from him, not just how to keep bees, but how to live a life of meaning, of purpose and of balance with the world.

Pic 2 : Passing the Torch: Young Minds Visit the Centenarian Beekeeper

The Legacy of the Bee Whisperer

As the sun sets over Rungli Rungliot, casting golden rays across the hills the bees begin to return to their hives just as they always have. And sitting quietly beside them is Mr. Rajman Moktan, watching, smiling, remembering the past golden memories.

His story is not written in history books. It won't appear on the evening news. But in every drop of honey, every buzzing wing and every person who has heard his story his legacy lives on.

He reminds us that greatness doesn't come from wealth or fame. Sometimes, it comes from a simple life lived with love, patience and a heart open to nature's wonders.

And as long as the bees keep buzzing in the hills of Darjeeling, the spirit of the eternal beekeeper of Rungli Rungliot will live on quietly, gently and forever.

Pic 3: With soil-stained hands and a humble heart, Rajman at 100 still continues to show that a life filled with love care, and purpose never truly grows old.

At 100 years old, while many would choose rest, Rajman Moktan still rises with the sun. His bees still hum his name and his small kitchen garden still welcomes his gentle hands. There he grows not just plants but memories nurturing organic vegetables and flowers with the same quiet devotion that shaped his life. Time may have slowed his steps and strength but his soul remains rooted in the earth blooming with purpose. His story is not just about bees or honey to tell it is about a man who chose to live simply and humbly who loved deeply and who gave the best of his wisdom to generations to come

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/26/0625

HOW SOIL CHEMISTRY INFLUENCES PLANT NUTRITION

R. Rebecca[1]*, S.U. Vikraman[2] and K. Suriya[3]

[1]PG Research Scholar (Soil Science and Agricultural Chemistry),
Department of Soils and Environment, Agricultural College and Research Institute,
Tamil Nadu Agricultural University, Madurai, Tamil Nadu - 625 104, India
[2]PG Research Scholar (Soil Science and Agricultural Chemistry),
Department of Soils and Environment, Agricultural College and Research Institute,
Tamil Nadu Agricultural University, Madurai, Tamil Nadu - 625 104, India
[3]PG Research Scholar (Soil Science and Agricultural Chemistry),
Department of Soils and Environment, Agricultural College and Research Institute,
Tamil Nadu Agricultural University, Madurai, Tamil Nadu - 625 104, India
*Corresponding Email: lovelyaxeber07@gmail.com

Abstract

Nutrient availability in soil is fundamentally linked to soil chemistry, which governs the forms and accessibility of essential nutrients for plant growth. Factors such as soil pH, cation exchange capacity, texture, organic matter, moisture, and microbial activity significantly influence nutrient retention and uptake. Proper soil management ensures nutrients remain available in forms plants can absorb, supporting healthy growth and high crop yields. Imbalances or adverse conditions can limit nutrient availability, affecting plant development and environmental health. Understanding these relationships is crucial for sustainable agriculture, enhancing soil fertility, reducing environmental impact, and improving food security. Soil testing and balanced nutrient management are vital for optimizing productivity and ecosystem resilience.

Keywords: Nutrient availability; Plant growth; Soil Nutrient; Soil composition

Introduction

Nutrient availability in soil is closely tied to soil chemistry, which refers to the composition of the soil in terms of its mineral and organic components. Understanding this relationship is crucial for successful plant growth, as the interaction between soil components and environmental conditions plays a significant role in determining the availability of essential nutrients. Various factors, including pH, moisture, temperature, and the presence of organic matter, influence how nutrients are retained, transformed, and made accessible to plants. Proper management of soil chemistry ensures that nutrients remain in forms that plants can readily absorb, supporting healthy and sustained growth.

The Soil Science Society of America defines available nutrients as the amounts of soil nutrients in chemical forms that are accessible to plant roots or in compounds likely to be converted into such forms during the growing season. However, the mere presence of sufficient total quantities of essential nutrients in the soil does not ensure their availability to plants. Factors such as soil moisture content, temperature, pH, physical structure, and the presence of toxic elements or salts can significantly limit nutrient availability, thereby affecting plant growth.

Nutrient available forms

Nutrient	Form used by plants	Nutrient	Form used by plants
Cations (+)		Anions (−)	
Nitrogen	NH_4^+	**Nitrogen**	NO_3^-
Potassium	K^+	**Phosphorus**	$H_2PO_4^-$ and HPO_4^{2-}
Calcium	Ca^{2+}	**Sulfur**	SO_4^{2-}
Magnesium	Mg^{2+}	**Boron**	H_3BO_3 and $H_2BO_3^-$
Manganese	Mn^{2+}	**Molybdenum**	$HMoO_4^-$ and MoO_4^{2-}
Copper	Cu^{2+}	**Chloride**	Cl^-
Zinc	Zn^{2+}		

Soil Chemistry and Its Influence on Nutrient Availability

pH Level : Soil pH is a critical factor that influences nutrient availability by affecting the solubility of minerals. It measures how acidic or alkaline the soil is. Most plants grow best in a slightly acidic to neutral pH range of 6.0 to 7.0. However, some plants have specific pH preferences. Outside the optimal range, certain nutrients may become either unavailable or toxic to plants.

Cation Exchange Capacity (CEC) : CEC is the soil's ability to hold and exchange positively charged ions, or cations, such as calcium, magnesium, and potassium. Soils with a higher CEC can store more nutrients and make them available to plants over time, which is vital for maintaining long-term soil fertility. This property is especially important in managing nutrient supply in agricultural soils.

Soil Texture : Soil texture refers to the relative proportions of sand, silt, and clay particles. It significantly influences water retention and nutrient-holding capacity. Sandy soils have large particles, allowing for quick drainage but poor nutrient retention. In contrast, clay soils have fine particles that can hold nutrients well, although they may suffer from poor drainage and aeration.

Organic Matter : Organic matter improves soil structure, enhances water retention, and supports beneficial microbial activity. It plays a key role in nutrient cycling by releasing essential nutrients through decomposition. As organic materials break down, they enrich the soil with nutrients that are readily available for plant uptake.

Soil Moisture : The level of moisture in the soil directly affects the movement and uptake of nutrients by plants. Both overly dry and excessively wet conditions can hinder root function and nutrient absorption. Consistent and adequate soil moisture is essential for optimal nutrient transport to plant roots.

Redox Potential : Redox potential refers to the oxidation-reduction status of the soil, which impacts the availability of specific nutrients, particularly iron and manganese. In waterlogged or poorly drained soils, redox conditions change, often leading to reduced nutrient availability and potential toxicity issues for sensitive plants.

Nutrient Interactions : Nutrients in the soil interact with one another, and these interactions can influence their availability to plants. An excess of one nutrient may inhibit the uptake of another, leading to imbalances. For example, high levels of potassium can interfere with magnesium absorption. Maintaining a balanced nutrient profile is crucial for healthy plant growth.

Microbial Activity : Soil microorganisms play a vital role in breaking down organic matter and converting nutrients into forms that plants can absorb. Their activity enhances nutrient cycling and overall soil fertility. Factors such as temperature, moisture, and organic matter content significantly influence microbial populations and their efficiency in nutrient transformation.

Soil Composition and Its Influence on Key Soil Properties

Soil Composition	Water Availability	Nutrient Availability	Oxygen Availability	Root Penetration Ability
Sand	Low: water drains out	Low: poor capacity for cation exchange; anions leach out	High: many air-containing spaces	High: large particles do not pack tightly
Clay	High: water clings to charged surface of clay particles	High: large capacity for cation exchange; anions remain in solution	Low: few air-containing spaces	Low: small particles pack tightly

The impact of nutrient availability in soil is profound and directly affects plant growth, crop yield, and overall ecosystem health.

1. **Plant Growth and Development** : Nutrients support vital plant functions like photosynthesis and enzyme production. Adequate nutrition leads to strong roots, healthy stems, and disease resistance. Balanced nutrients ensure optimal growth throughout the plant's life cycle.
2. **Crop Yield and Quality** : Essential nutrients directly impact the quantity and quality of harvests. Deficiencies reduce yield, shrink fruit size, and lower nutritional value. Proper nutrient management enhances both productivity and food quality.
3. **Nutrient Uptake Efficiency** : Soil pH, CEC, and organic matter affect how well plants absorb nutrients. Efficient uptake reduces nutrient loss and supports healthy growth. Balanced conditions ensure maximum benefit from applied nutrients.
4. **Environmental Impact** : Excess nutrients can run off into water, causing pollution and algal blooms. This leads to oxygen depletion and damage to aquatic ecosystems. Sustainable practices reduce runoff and protect the environment.
5. **Soil Fertility and Health** : Nutrient-rich soils support long-term productivity and biodiversity. Balanced nutrients improve structure and biological activity in soil. Practices like crop rotation help sustain fertility over time.
6. **Economic Impact** : Nutrient availability influences crop success and farm profitability. Overuse or imbalance raises costs and reduces returns. Effective management lowers input costs and boosts yield.
7. **Global Food Security** : Nutrient-rich soils help produce enough food for growing populations. Poor nutrition in soil can lead to hunger and malnutrition. Sustainable farming ensures a stable, nutritious food supply.
8. **Adaptation to Climate Change** : Well-nourished plants are more resilient to drought and heat. Healthy soils improve water retention and reduce stress impact. Optimizing nutrients helps ecosystems adapt to climate shifts.

Conclusion

Understanding soil chemistry and nutrient availability is key to promoting healthy plant growth and sustainable agriculture. Proper soil management ensures that essential nutrients are accessible to plants when needed. Soil testing provides critical insights into nutrient levels and guides efficient fertilizer use. By managing soil wisely, we enhance crop yield, protect the environment, and support long-term food security.

Reference

Tan, K. H. (2010). Principles of soil chemistry. CRC press.

Strawn, D. G., Bohn, H. L., & O'Connor, G. A. (2019). Soil chemistry. John Wiley & Sons.

Hartz, T. K. (2007). Soil testing for nutrient availability: procedures and interpretation for California vegetable crop production. Dept. of Plant Sciences: Davis, CA, USA.

Dhotare, V. A., Guldekar, V. D., Bhoyar, S. M., & Ingle, S. N. (2019). Evaluation of soil nutrient index and their relation with soil chemical properties of washim road farm of Dr. PDKV Akola, Maharashtra, India. Sciences, 8(9), 1773-1779.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/27/0625

FROM WASTE TO WEALTH: HOW INSECT FRASS BOOSTS SOIL WITHOUT SYNTHETICS

Pungavi Ramakrishnan[1]*, Bala Murgan S[2] and Priyadharshini Velayutham[3]

[1]*Assistant Professor, School of Agricultural Sciences, Joy University, Vadakangulam, Tirunelveli – Tamil Nadu.
[2]Assistant Professor, Sri Venkateswaraa University, Ettayapuram, Thoothukudi, Tamil Nadu.
[3]Assistant Professor, SRS Institute of Agriculture and Technology, Vedasandur, Dindigul - Tamil Nadu, India.
Corresponding Email: r.pungavientomology@gmail.com

Introduction

Insect farming industry is expanding in response to an increasing demand for sustainable protein sources for feed and food. With an annual growth of 28% and projected market value of $18 billion USD by 2033. Moreover, insect rearing has fewer greenhouse gas (GHG) emissions than swine and beef cattle industries. However, with growing concerns about soil degradation, climate change and the environmental harm caused by synthetic alternatives, scientists and agricultural tech innovators are finding a solution in an unexpected place: Insect waste.

What is Insect frass?

Insect frass it is a mixture of insect droppings, shed exoskeletons, and leftover feed from insect farming. For ages, farmers have depended on traditional fertilizers to feed their land and maintain crop yields. This is a mixture of insect excrement, undigested feed, and shed exoskeletons. Insect frass is rich in nutrients and organic matter and is emerging as a "green" fertilizer that supports soil health, plant growth, and even pest resistance.

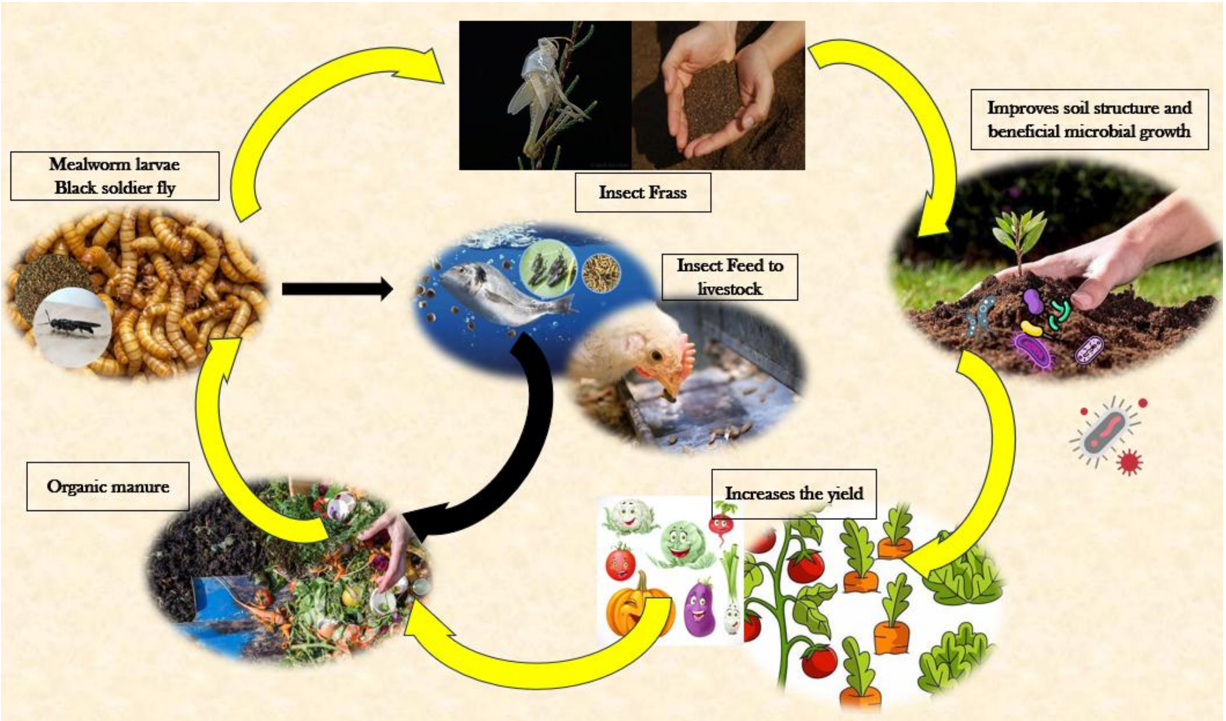
Benefits of Frass Application in Agriculture

Enhanced Soil Fertility

The most immediate benefit of insect frass lies in its capacity to boost soil richness. Studies reveal that adding frass to soil elevates its organic matter, enhancing both water and nutrient retention. For instance, tomato plants cultivated in frass-treated soil exhibited a 25% greater nutrient absorption compared to those receiving only synthetic fertilizers. Notably, yellow mealworm frass showed remarkable potential, effectively doubling the soil's carbon content and tripling its nitrogen content a considerably higher impact than sources like poultry litter or ammonium nitrate. Crucially, this frass-enriched soil yielded comparable crop harvests and carbon dioxide emission rates.

Boosting Microbial Activity and Disease Resistance

Frass effectively reduced aphid infestations in lettuce by 40% due to its ability to trigger plant immune responses; however, heat-treated frass, necessary for pathogen safety, can diminish its microbial benefits (e.g., sterilization reduced Bacillus populations in mealworm frass by 50%), so farmers aiming for pest control should opt for fresh, non-sterilized frass or integrate it with compost to replenish microbial content.



Improving Soil Structure

Beyond its nutritional value, frass enhances soil structure by increasing organic matter, which improves aeration and porosity for better root access to nutrients, leading farmers who use it to report improved soil aggregation, reduced erosion, and enhanced long-term soil health.

Future Feed for Biogas plant

Beyond its well-established role as a fertilizer, insect frass also holds remarkable potential for bioenergy production. For example, Black Soldier Fly (BSF) frass can yield a substantial 150–200 cubic meters of methane per ton—a quantity quite comparable to that derived from cow manure. This opens up avenues for farmers to not only recycle agricultural waste but also to simultaneously generate renewable energy. Moreover, when utilized as a feedstock, frass has been shown to significantly enhance the output of other valuable resources, such as boosting protein yield in algae like *Chlorella* by a notable 40%.

Farmers now have an exciting new revenue stream beyond simply selling larvae and pupae for livestock feed: insect frass. This valuable byproduct offers an opportunity to generate additional income by supplying it to the agricultural community, enabling more sustainable farming practices and significantly reducing environmental impact through enhanced crop yields.

Challenges and Considerations

One significant obstacle to wider adoption is the lack of standardized nutrient profiles, as the composition of frass can fluctuate considerably based on the insect species, their diet, and the specific rearing conditions. To mitigate this variability and ensure safety, regulatory bodies, such as the European Food Safety Authority (EFSA), have instituted stringent guidelines mandating heat treatment for frass prior to its commercial release, thereby guaranteeing its freedom from pathogens. A further concern revolves around the potential presence of anti-nutritional factors within frass. While generally benign for plant life, an overzealous application could conceivably precipitate nutrient imbalances.

Conclusion

With the global fertilizer market anticipated to surpass an astounding $240 billion by 2027, insect frass emerges as a remarkably promising and sustainable alternative. It perfectly embodies the principles of circular agriculture by transforming organic waste into potent, nutrient-rich soil amendments. This innovative approach paves a clear path toward both regenerative farming and the cultivation of truly resilient food systems.

Reference

No waste left behind: Insect droppings can improve soil fertility

Gebremikael MT, Wickeren Nv, Hosseini PS and De Neve S (2022) The Impacts of Black Soldier Fly Frass on Nitrogen Availability, Microbial Activities, C Sequestration, and Plant Growth. *Front. Sustain. Food Syst.* 6:795950. doi: 10.3389/fsufs.2022.795950

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/28/0625

LIVESTOCK SECTOR: A BOON OR BANE TO THE INDIAN FARMERS AND ECONOMY

Neetu Nehra*, Sarthak and Pulkit Chugh

Department of Animal Husbandry and Dairying, Haryana
*Corresponding Email: neetu.nehra008@gmail.com

Introduction

Livestock rearing activity has gained importance in the rural areas of country and contributing significantly to the economic prosperity of our nation. The increasing human population coupled with financial improvement and urban development has a significant impact on livestock production, especially through growing demand for animal derived protein. It not only provides income to many landless households but livestock also act as a source of protein in the form of milk, egg and meat. Previously, livestock production represents an important subsidiary occupation for an assured year-round income to the farmers to cope up with uncertainties related with agriculture production. But changing diets and vagaries of climate change makes animal farming a safer option than agriculture in rural areas. Due to its enormous potential for value addition, notably in the meat and milk processing industry, this Indian livestock sector is poised for massive expansion, increasing its contribution to world livestock commerce every year. Technology has advanced a lot in this field, there are a lot of new equipment that has been introduced along with development of new techniques like IVF, ET, AI, Progeny testing, sex sorted semen.

Livestock and its importance

The livestock sector not only being an important source of income to farmers but also an integral part of nutrition and food security worldwide. Apart from food, it also provides important products and services which are of immense importance to the public at large like asset saving, manure for fuel and fertilizer, fibres, traction etc.

Food

The livestock provides food items such as milk, meat and eggs for human consumption and dairy sector is the largest single agricultural commodity, accounting for five percent of the national economy. According to the reports of 20th livestock census published by DHAD, India continues to be the largest producer of milk in world accounting for 25 percent of world's milk production whereas meat and egg production has shown positive growth as 4.95%, 3.17% during 2023-24. Milk, egg and meat production during 2023-24 is 239.30 million tonnes, 142.77 billion and 10.25 million tonnes respectively and the per capita availability of milk and egg is around 471 grams/day and 103 eggs per annum respectively in 2023-24. The livestock sector is a vital sector of India's economy and sector grew at an impressive Compound Annual Growth Rate (CAGR) of 8% constant prices. It provides employment to about 8.8% of total population against total GVA growth of 6% (2014-23). The contribution of livestock to the total GVA (at constant prices) in agriculture and allied sectors increased from 24.32 % in 2014-15 to 30.23% in 2022-23.

Role in women empowerment

Livestock plays a vital role in upliftment of women empowerment and farmer's economy. Women producers makes the significant labour/work force of the dairy sector in the country. This sector is a significant work supplier, particularly for women, and plays lead role in strengthening women.

Fibre and Skins

Livestock also furnishes wool, hair, hides and pelts production. The wool production of the country in 2023-24 stood at 33.69 million kgs and total wool exports from 2017-18 till 2021-22 (until January 2022), grew at a CAGR of about 2.7%. Leather industry in India has a very high export potential and bestowed with an abundance of raw materials as India is endowed with 20% of world cattle & buffalo and 11% of world goat & sheep population. India accounts for 13% of world leather production of hides/skin and produces 3 billion sq. ft leather annually.

Sports / Recreation/ Companion Animals

Dogs are known for their loyalty, devotion and have been used as companions since ancient time. Even though animal competitions (like cockfights, ram fights, and jalli kattu) are prohibited/banned; cocks, rams, and bulls are used for these competitions and sports by people as a stress buster mainly during festive season in the country.

Transportation and Draft

Pack animals like camels, ponies, jackasses, horses and donkeys are widely used to move merchandise in various areas/parts of the country. In circumstances like uneven territories/ hilly areas donkeys, mules and horses act as the main choice to ship products. The military have to rely on these pack animals not only for transportation various items in high altitude areas but militiamen also use camels for watching and patrolling the border line regions. Numerous Indian farmers' agricultural activities, particularly those in rural areas, continue to rely on bullocks despite numerous advancements in the use of mechanical power. Draft animals are saving a ton of fuel which is a vital contribution for utilizing mechanical power like farm vehicles, join gatherers and so on and thus, bullocks are the foundation of Indian agribusiness.

Research/Medicinal Purposes

Animals are used as models to study many emerging/ reemerging diseases and thus advances our scientific understanding. In current era use of animals is a necessary component of drug discovery process and both allopathy and Ayurveda uses animal products and by-products for treatment purposes. Panchgavya has ability to cure many chronic diseases viz. cancer, diabetes etc.

Storage

Domesticated animals are considered as 'moving banks' a result of their possibility to arrange off during crises. Livestock act as a main capital asset and resource to landless farming workers and labourers and in emergency crises they act as assurance for getting loans from the moneylenders in rural areas.

Weed Control

Livestock by grazing on the weeds in fields before sowing also play a biological role in shrubs, plant and weed control and thus improve tillage.

Dung and Other Animal Waste Materials

Due to the rising pattern of organic farming, the compost from animal waste is in high demand. Dung and other animal wastes, including urine, litter, and discarded scraps, are excellent farm yard fertilizer/manure and are worth several crores of rupees. Furthermore, it is additionally utilized as fuel in form of bio gas, dung cakes and for development as poor man's concrete.

Constraints and Challenges in Livestock Sector

Livestock farming definitely looks easy but is not, it needs a lot of hard work, skills, and patience to maintain the good health and proper nutrition of farm animals. It needs skilled manpower but farm earnings are relatively low, owing to low pricing at the farm gate, despite trained workers/labourers, excellent equipment, fertile soil, and subsidies. Low wages, expensive land prices, and a scarcity of available farmland deter young people from entering the profession. The risk factors associated with livestock farms includes: climate change, pasture management, animal health and disease prevention.

Shortage of Feed and Fodder

The ICAR-Indian Grassland and Fodder Research Institute (IGFRI) has estimated that there is deficit of 11.24, 23.4 and 28.9 per cent for green fodder, dry fodder and concentrates respectively in the country. Dietary deficiency of various nutrients affects not only growth and milk production but also reproduction like low levels of protein adversely affect the reproductive system and also disrupt the oestrus cycling. The main causes of fodder shortages are the decline in land ownership, estimated at per capita, and the loss of forest land, which revealed resources-based land per head of livestock. However, in recent years forage-based research organizations have presented various techniques and advice to emphasize food supply, land acceptance, and the impact of these interventions has been very limited in India. Due to increasing livestock population, there is shortage in supply and thus to bridge the gap between demand and supply, urgent steps need to be taken. Apart from non-availability or poor availability of green fodder and legumes round the year, lack of awareness about treatment of poor-quality straw to improve its nutritive value, lack of knowledge about proper amount of concentrate feeding, distant location of market for purchase of concentrate and mineral mixture, lack of knowledge of balanced feeding among farmers, high cost involved in purchase of ingredients concentrate mixture are some other feeding related constraints in livestock farming.

Increasing Diseases

With improvement in the quality of livestock through cross-breeding programmes, the susceptibility of these livestock to various diseases including exotic diseases has increased. Severe inadequate facilities for diagnosis of the disease, lack of awareness about the importance of vaccination, lack of adequate resources with farmers for better management and treatment of sick/ diseased animals, lack of knowledge regarding importance of isolating the diseased animals and disposal methods of diseased animal carcass, unhygienic environment in animal sheds/farms, lack of knowledge about symptoms of common contagious diseases and their prevention measures, unhygienic housing and poor transports facilities to attend the cases well in time by expert are some other constraining factors responsible for increased incidence of animal diseases.

Low Productivity

Low productivity in terms of milk yield is one of the major constraints associated with animal farming. Average poor feeding practices, sub-optimal nutrition, local breeds, scarcity of resources to maintain crossbred / superior breed of milch animals, improper managemental practices and low milk prices are the primary reason for low milk production.

Inadequate land/ Consolidation on land holding

Land/Space is needed to produce and store feed, house animals and recycle animal waste however lack of security in land tenure is still a huge problem for many herders. One of the problems of proper management is consolidated land holding, scattered in small plots in and around the village. The farmers found difficulties to make long term investment in creating building facilities and other land improvement.

Inadequate Veterinary Services

Non availability of livestock extension officers and veterinary doctors in time, distant location of veterinary dispensary, lack of infrastructure facilities in veterinary hospitals, poor transports facilities to attend the cases well in time by veterinarians, high cost of veterinary medicine and vaccines are also some challenging factors in this sector.

Poor Breeding Facilities

The cattle/buffalo development programmes were suffered on account of poor genetic potential of bull or lack of good breedable bulls. The available facilities for breeding were not utilized properly due to lack of A.I. Centre, poorly equipped A.I. Centre, lack of services at A.I. Centre and distant location of veterinary hospital. Other factors which are associated with poor breeding includes anoestrus and repeat breeding, large numbers of village under one Livestock Extension Officer, poor conception rate and preference of natural service by Indian farmers.

Inadequate livestock extension services

Extension services play a major role not only in spreading the science-based knowledge to farmers but also makes them aware about the schemes introduced and implemented by government in this particular field. This might be challenged due to lack of efficient communication between research institute, extension services and farmers. Target area for livestock extension services is very limited and poor as farmers are not aware of recent development in the area of livestock sector like development in animal nutrition, particularly improved utilization of existing feed resources, strategic supplementation of roughage-based diet, uses of common salt and mineral mixture in improving the animal health, production, reproduction and feeding of colostrum to newly born calves.

Ignorant Managemental Practices by farmers

Malpractices followed by farmers at most of farms due to lack of sufficient managemental knowledge and high-cost investment in scientific management of animals. Constraints in adoption of improved management practices by farmers also includes scarcity of clean drinking water facilities for animals, inadequate credit facilities for purchasing necessary input, limited space and improper housing due to lack of resources (lack of scientific housing facilities), lack of knowledge about clean milk production, cleaning and sanitation of animals and cattle shed. This may occur due to lack of proper communication, awareness about improved management practices, education and extension contacts.

Environmental Impacts/ Climate change

The generation of greenhouse gas emissions is the most important environmental impact as far as livestock farming is concerned. As the emissions from livestock increases, many changes concerning the atmosphere, the land and the oceans are occurring that lead to climate change. Current reports suggested that India is the world's third largest greenhouse gas (GHG) emitter and agriculture sector is the second largest emitter accounting for 21% of total green-house gas emissions. Of this total, the share of feed production and processing is approximately 45%, the share of enteric fermentation is approximately 39%, and the share of manure management is approximately 10%. The processing and transportation of animal products account for the remaining 6%. The significant amounts of GHG emissions are produced either through their physiological processes or during the production of animal origin products. The livestock sector is responsible for 14.5% of total anthropogenic GHG emissions. CH_4 from enteric fermentation accounting for 32% and manure management contributing another 16%. Cattle production is the largest contributor to global livestock emissions, contributing 61%, while other species contribute much less: pigs (9%), poultry (8%) and small ruminants (6%). Mitigation strategies need to be adopted in the livestock sector to reduce the environmental impact.

Credit and Marketing Facilities

Lack of transport infrastructure, cold storage, and processing facilities are constraints associated with marketing. As a result, most animals are traded as live animals without value addition and irrespective of the risk of transmitting transboundary animal diseases. Moreover, institutional support and government policies are not well aligned with strengthening local and external markets and promoting market access to producers. livestock farming's primary objective is to meet the subsistence requirements of livestock products for the household, but concerning the marketing side of livestock productions, live animals' sale as a cash reserve is very common; however, some degree of small-scale animal trades is also present. The local market system heavily depends on small networks of exchange-based channels that operate under personal and ethnic relations. A bargaining approach is used to determine the price of the animal rather than a live weight-based method.

Socioeconomic Constraints

Socioeconomic pressures are another set of constraints limiting livestock productivity. Most of the livestock farmers are smallholders and are deprived of financial resources such as loans, credit schemes, and insurance. Although adult males predominantly manage livestock farming, women and children play significant roles in livestock-related livelihood operations. Most of the small ruminant species and poultry are managed by women and the younger population. Moreover, women are more involved in managing milk collection, processing, and value-addition due to its relevance to child nutrition. However, the productivity of women-managed livestock systems is often lower than the ones managed by men because of limited access to inputs, extension services, and modern techniques, in addition to social barriers.

Weakened institutional capacities and ineffective livestock policies

The livestock sector is also affected by poor institutional capacities for research and extension due to limited investment and lack of funding for capacity development. Moreover, most of the current policies are ineffective and outdated, thus not supporting the growth and development of the sector. Lack of reliable livestock production statistics is the primary reason for ineffective policies.

Conclusion

It has been concluded that livestock farming is vital for the economy, food, and nutritional security and shaped by demographical, economic, environmental, and sociopolitical challenges. Identification of main challenges that limit production of the livestock farming sector and potential interventions for improving the overall performance of this sector should be focused. Potential interventions should be made to maximize the synergies of productivity improvement in the livestock farming regions. But this sector along with associated various micro and medium enterprises will not only provide employment but will strengthen the economy also.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/29/0625

FROM WILD GRASS TO LIFELINE: THE JOURNEY OF RICE THROUGH HISTORY AND BEYOND

Debobrata Dey[1], Snehasree Samanta[1] and Arnab Mandal[2*]

[1]Division of Genetics and Plant Breeding, School of Agriculture and Rural Development,
Ramakrishna Mission Vivekananda Educational & Research Institute,
Narendrapur Campus, Kolkata, West Bengal, India
[2]Department of Genetics and Plant Breeding, Midnapore City College,
West Midnapore, West Bengal, India
*Corresponding Email: arnabmandal.gpb@gmail.com

Abstract
From ancient river vallys to modern genetic labs, rice (*Oryza Sativa* L.) played a pivotal Role in shaping human history, culture and food systems. Domestication over 10,000 years ago in both Asia and Africa, rice evolved through independent pathways into one of the world's most critical staple crops. This article traces its evolution from wild grass to a symbol of empire, economic power, and global diplomacy. It explores the significance of rice in ancient civilizations, its exploitation during colonial times, and its revolutionary transformation during the Green Revolution. With more than half of the world's population relying on rice today, the crop's future hinges on climate smart innovation and environmental and sustainable practices. As we confront global food insecurity and environmental challenges, rice remains not just a grain, but a cornerstone of resilience and hope for generations to come.

Keywords : Domestication, Oryza sativa, Green Revolution, Food security, Sustainable agriculture.

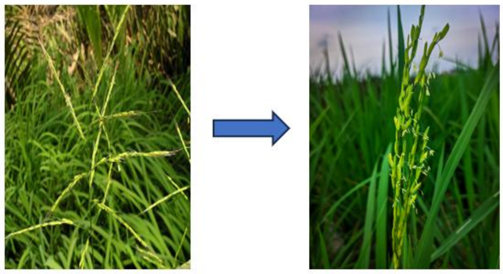
Introduction
From ancient terraces caved into misty hillside to high-tech research labs decodling its genome, rice has shaped civilizations, economies and diets like few other crops. Today, it remains the most influential grain on Earth. More than half the world's population relies on rice as a staple food every day. But rice (*Oryza sativa* L.) is far more than just nourishment it is a symbol of heritage, a subject of cutting-edge science, and a strategic crop at the heart of global food security. With 90% of production and consumption centered in Asia, rice plays a foundational role in the livelihoods and diets of billions (Fukagawa & Ziska, 2019). Its transformation from a wild grass into a globally vital crop is a story of innovation, adaptation and survival.

The Origins and Domestication of Rice
The domestication of rice, a foundational staple for much of the global population, began around 10000 years ago in two primary regions: the Yangtze River valley in China and the Ganges Basin in India (Sangeetha *et al.*, 2020). This era marked a pivotal change in human development, as communities moved from foraging to establishment settled agricultural practices centered on rice cultivation. The process involved the gradual transformation of wild rice species through ongoing human selection.

Wild origins of rice
Oryza sativa, the dominant Asian rice species, evolved from its wild ancestor, *Oryza rufipogon*. Genetic research has revealed significant complexities in the relationships between cultivated rice and its wild relatives, prompting debates over the exact pathways and regions of domestication

(Sangeetha *et al.*, 2020). Genome studies suggested that multiple regions, such as India and parts of Indochina, may have independently domesticated rice (Shao *et al.*, 2021).

Two paths of domestication: Rice is notable for its independent evolution into two major cultivated species, *Oryza sativa* (Asian rice) emerged in Asia and is now the most widely grown rice globally. Its development involved major genetic shifts through both natural and human directed selection. *Oryza glaberrima* (African rice) was independently domesticated in West Africa. It is less widespread today, but remains vital in specific African regions and offers important genetic resources for crop improvement (Choi *et al.*, 2018).



Wild Rice *Oryza rufipogon* | Cultivated Rice *Oryza Sativa*

Fig 1. Evolution of Rice

Empire of Grains

Rice played a vital role in the development and sustenance of early Asian empires, including those in China, India and Southeast Asia. Its cultivation spread through various means such as trade, conquest and migration, influencing agricultural practices and diets across the continent. The cultivation of rice also extended beyond the core region of Japan, Korea and other areas, further solidifying its importance in East Asian Agriculture. Techniques like terraced fields and sophisticated irrigation systems were developed to maximize rice production, often relying on intensive labor systems to manage and maintain these complex agricultural landscapes.

Grain Diplomacy

Rice, as a dietary staple for over half of the global population, has long been interwoven with the political and economic frameworks of civilizations. Historically, it played a pivotal role in the formation of empires by supporting large population and shaping system of taxation and warfare logistics. During the colonial era, European and American powers harnessed rice cultivation to fuel export-oriented plantation economics in regions like the Americas and West Africa, often relying on coerced labor and neglected local food needs (Zandstra *et al.*, 2023). This exploitative model significantly impacted the health and food security of indigenous communities. In modern contexts, rice remain central to national and global food security strategies, as seen in India’s Green Revolution and ongoing international food aid programs. However, challenges such as environmental degradation, climate change, dependency on aid necessitate the adaptation of sustainable, climate-resilient rice cultivation practices. The historical and ongoing nexus between rice, power, and policy underscores its critical role in global geopolitics and development.

The Green Revolution

The Green Revolution marked a turning point in agricultural history, driven by the introduction of high-yielding varieties (HYVs) of staple crops such as rice and wheat. Pioneered by scientist like M.S. Swaminathan in India and Philippines, the movement aimed to combat widespread hunger and poverty by boosting food production on a massive scale. The creation of semi-dwarf rice varieties, notably IR8 in the 1960s, significantly enhanced yield capacity and marked the onset of Asia's Green Revolution. Combined with the expanded use of chemical inputs and irrigation, these innovations were instrumental in preventing famine and feeding a rapidly growing global population. Between 1966 and 1990, food production in densely populated, low-income nations more than doubled, despite an 80% rise in population. Here is the flow chart that represents how wild rice evolves to the cultivated rice through various intermediate processes year after year and still continuing.

Wild Rice (Oryza rufipogon) - ~13000 BCE

↓

Domestication Begins (China's Yangtze Valley) - ~8000–6000 BCE

- Start of intentional planting
- Traits selected: non-shattering seeds, larger grain

↓

Development of Oryza sativa subspecies:

- Indica (South Asia) - ~6000–4000 BCE
- Japonica (East Asia) - ~6000–4000 BCE

↓

Diversification & Traditional Landraces - 1000 BCE – 1800 CE

- Local adaptation
- Cultural integration

↓

Scientific Breeding & Hybrid Varieties - 1800s–1900s

- Introduction of irrigation systems
- Cross-breeding programs

↓

Green Revolution - 1960s–1980s

- High-Yielding Varieties (HYVs)
- IR8 and other semi-dwarf rice

↓

Modern Genomics & GMO Rice - 2000s–Present

| • Marker-assisted breeding

| • Golden Rice, climate-resilient varieties

Conclusion

From its humble beginnings as a wild grass to becoming the lifeline of billions, rice's journey is nothing short of epic. As the global population continues to surge, the grain that once fed ancient civilizations must now adapt to feed the future. With pressing environmental challenges and the demand for both quantity and quality, the path forward lies in innovation through sustainable practices, climate-smart farming, and cutting-edge breeding techniques. The story of rice is far from over. It is a living narrative of resilience, transformation, and hope one that will continue to shape global food and nutritional security in the future.

Reference

Choi, J. Y., & Purugganan, M. D. (2018). Multiple Origin but Single Domestication Led to *Oryza sativa*. *G3 Genes|Genomes|Genetics*, *8*(3), 797–803.

FUKAGAWA, N. K., & ZISKA, L. H. (2019). Rice: Importance for Global Nutrition. *Journal of Nutritional Science and Vitaminology*, *65*(Supplement), S2–S3.

Sangeetha, J., Thangadurai, D., Fayeun, L. S., Akinwale, J. A., Habeeb, J., Maxim, S. S., Hospet, R., & Islam, S. (2020). Origin and Evolution of Rice as Domesticated Food Crop. In *Rice Research for Quality Improvement: Genomics and Genetic Engineering* (pp. 1–14). Springer Singapore.

Shao, K., Zhang, J., Lu, H., Gu, Z., Xu, B., Zheng, H., Sun, G., Huan, X., He, K., Zou, Y., & Wu, N. (2021). Process of rice domestication in relation to Holocene environmental changes in the Ningshao Plain, lower Yangtze. *Geomorphology*, *381*, 107650.

Zandstra, M., Byerlee, D., & Lynam, J. (2023). Rice: The Colonial Origins of Food Crop Research in West Africa. *Journal of Colonialism and Colonial History*, *24*(2).

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 05/VI/30/0625

MECHANISM AND EXAMPLES OF SEX LINKED; SEX LIMITED; SEX INFLUENCE INHERITANCE

P. Lasya Prasuna, D. Mamatha, P. Anand Prasad, M. Joshna*, Salkapuram Sandeep Kumar, SK. Sameera, M. Shiny Rachel and N. Arun Kumar
Department of Aquaculture, Andhra Pradesh Fisheries University,
College of Fishery Science, Muthukur – 524 344
*Corresponding Email: joshnamalreddy@gmail.com

Abstract
Sex chromosomes play a critical role not only in degerming the sex of an organism but also in the inheritance of several non-sexual traits. The article revies the three key patterns of inheritance associated with sex chromosomes and hormones: sex linked, sex limited, sex-influenced inheritance. Sex linked traits usually on the X chromosomes and exhibit characteristic inheritance patterns. Sex limited genes are expressed in only one sex, often due to hormonal influence, despite being present in both. Sex influenced genes are autosomal but their expression varies depending on the individual's sex. Through classical examples in Drosophila melanogaster and humans, we exp the explore the genetic and hormonal factors affect these inheritance patterns.

Keywords: Chromosomes, Hormones, Inheritance, Sex-linked, Sex-limited, Sex-influenced, X-linked

Introduction

Inheritance refers to the process by which genetic traits are passed from parents to offspring's. All chromosomes other than sex chromosomes are called "Autosomes ".Genes located on X chromosomes are called " sex linked gene" .They have a special pattern of inheritance unlike those situated in autosomes .The sex linked traits may be recessive or dominant .The female with 2 chromosomes may be either heterozygous or homozygous for a given gene .Accordingly the trait in the female may show recessive or dominance .But the males having XY chromosomes will have heterozygous condition .The gene in the X-chromosome will not have an allele in Y-chromosome.

Sex linked inheritance

Sex linked inheritance refers to the carrying of genes by the X-chromosomes for body characters; also called as X-linked inheritance. The main characteristic of X-linked inheritance whether it is dominant or recessive. The father to son is absent. This is due to the fact that the X-chromosome in the male is never transmitted to his sons. But are passed on to his daughters. X-chromosomes in female individual will be distributed equally among daughters and son.

Sex linked inheritance in *Drosophila melanogaster* [fruit fly]:

IN 1910, T.H.Morgan a geneticist and a noble laureate of Columbia university working with culture of *Drosophila melanogaster ,* He discovered " sex- linked inheritance" In a culture of red eyed drosophila .He found that one of the male flies in the culture has white eyes .If this male white eyed fly mated with a red eyed female, the F1 generation offsprings are red eyed .All red eyed offsprings indicates the white colour recessive to normal red colour. w- allele for red eye ;*w*-allele for white eyes.

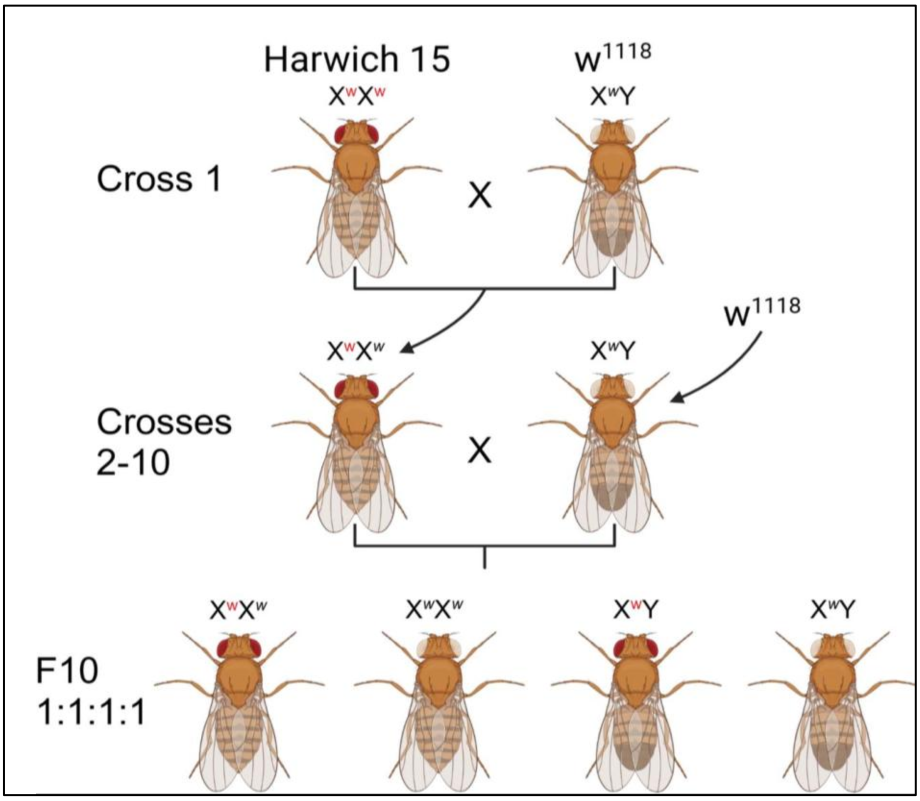


Fig 1 Sex Linked inheritance in Drosophila (April Rickle, 2025)

If these F1 flies are inbred, all the females of the F2 will have red eyes and half of the males will have red eyes and other half white eyes. No white eyed females are found in F2 generation. Morgan found an explanation for this based on the chromosomal basis of sex determination. He found in drosophila, The somatic cells of the males have heterogametic condition [XY], Whereas the females are homogametic [XX]. Morgan hypothesized that the gene for eye color follows the X [sex chromosome] pattern of inheritance. The alleles for white and red eyed were located on X-chromosome. Only the daughter receives X-chromosome from the male or father [white eyed male parent] and both the sons and daughters receive X-chromosome from the female or mother. The allele for eye colour is absent in the Y-chromosome.

Thus, the male flies transmit X-LINKED INHERITANCE to his grandsons through his daughters but never through sons.

Sex-linked inheritance in humans [color blindness]

E.B. Wilson discovered that in man daltonosim [red-green colour blindness] is due to a X-linked recessive gene. Individuals with this disorder cannot distinguish red and green colors. The retina of the eyes contains colour sensitive cells which are necessary for distinguishing red and green colors. Formation of such colour sensitive cells is controlled by a gene located on X-chromosomes. The dominant allele of this gene is responsible for the development of these colour sensitive cells. The recessive allele prevents their development. The Y-chromosomes do not have the gene for colour blindness and so the Y-chromosome does not play any role in the inheritance of colour blindness. The X-linked recessive gene is able to express this trait in the males, because the males have only one X-chromosome. On the other hand, females have two chromosomes and in the heterozygous condition colour-blindness is not expressed. Females will be colour-blind only when the individuals

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

are homozygous for this recessive allele. That is why colour -blindness is more frequent in men than in women. It occurs in 8% of the male and 0.5% of the female populations. If a colour blind man marries a normal woman all the children would be normal. Because, the son receives the X -linked dominant allele **[C]** for normal vision from his mother and the daughter receives and X-linked dominant allele for normal vision from her mother and a X-linked recessive allele **[c]** from her father Diagram illustrating sex linked inheritance in man [color blindness] white X-chromosomes carry normal allele **C**; black X-chromosomes carry recessive allele **c,** for color blindness; hooked Y-chromosomes.

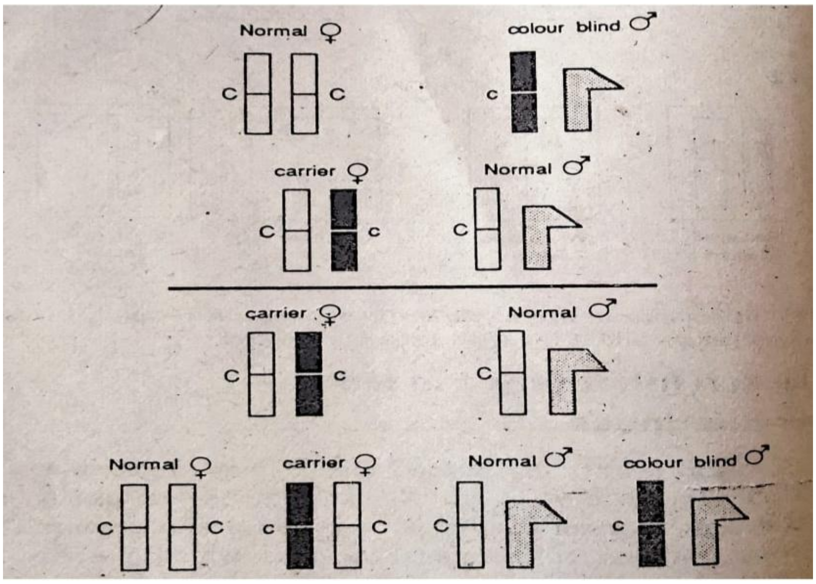


Fig 2 Sex linked inheritance in human (Colour blindness) (Prakash, 1997)

When the daughter will the genotype, carrier marries a normal man, color blindness occurs among half of the grandsons of the original parents. A color -blind girl can be produced only blind woman. Thus, in man color blindness is transmitted from male to his grandsons through his daughters. It cannot be transmitted to or through sons. These disorders also follows the criss cross inheritance.

Y-Linked inheritance in man

Genes of some body characters are carried by Y-chromosomes. So, such characters are not inherited by the females. For example the Y-linked inheritance of colour patterns in male *Poecilia reticulata* was reported by O.Winge (1992). Genetics located on the Y-chromosomes are transmitted from father to son. Thus Y-linked phenotypes are seen in only one sex, males. Phenotypes that are Y-linked guppy are

Yma - maculatus pigmentation
Yds - double sword tail
Yar - armatus pigmentation

The maculatus gene in the guppy, which controls the maculatus pigmentation (black spot on the dorsal fin and a red spot on the body). And other examples in humans like

1. Hypertrichosos: In some families long stiff hairs on the rim of the ears are present in all he males; in all the males; but not in females.
2. Icthyosos Hystrix: The presence of scaly skin is inherited by Y- linked gene.

Sex limited genes

Genes whose expression is limited to one sex only are called “sex limited genes”. These genes are different from sex linked genes as located only on the sex chromosomes, whereas the sex -limited genes may be located on any of the chromosomes including the sex chromosomes. In mammals and in birds, the expression of such genes depends upon the presence or absence of the sex hormones. Hormones like testosterone and estrogen plays a crucial role in regulating the genes expression sex limited genes are responsible for many of the primary and secondary sexual characters. The proper balance of hormones determines the normal expression of the certain genes.

Beard in man

In human being a woman normally does not have a beard. But she carries all the genes necessary for beard growth. Her son will receive these genes and these genes will be expressed. However, these genes will act only when male hormones [androgens] are present above a certain level. Sometimes, in some women, due to pathological conditions more male hormones will be secreted. For example, the presence of tumor can raise the level of androgens in women. This will cause the growth of beard in women. Another example is the development of breast which is limited to the females. males and females carry gene for this character. however, their expression depends on a certain level of estrogen [female hormone]. In the males, estrogen level is low, whereas in the females is high. This is the reason for the development of breast in the female.

Sex influenced genes

There are genes whose expression varies according to the sex of the individual in which they occur. These genes are expressed in both the sexes, but they behave dominant in one sex and recessive in other. Such genes are sex influenced genes. These genes are located on the autosomes.

Baldness in human

Baldness in man may result due to diseases, seborrhea, syphilis, thyroid diseases etc. But pattern baldness depends on heredity. It is more common in men than women. This leads us to think that it may be due to sex linked recessive inheritance. But the differentiation is from the fact that when a father is bald, he transmits baldness to about half of his sons, which is seldom seen in sex linked inheritance. This is not sex linked dominant because not many women than men show the character.

Genotypes	Phenotypes	
	Males	**Females**
BB	Bald	Bald
Bb	Bald	Non-bald
bb	Non-bald	Non bald

If we represent B as a gene for baldness and **b for** non-bald.

Baldness in man is due to sex influenced genes. Its allele b for non-bald nature behaves as a dominant females and recessive in males. Hence bald women must have BB genotype; bb to retain hair [non bald]. But the expression of the heterozygous genotype [Bb] is influenced by the sex of the individual. The males with the genotype Bb are bald and the Bb females are non-bald even though they have allele for baldness. As in the case of sex-limited genes, it is proved that the internal sex hormone level is the cause for the kind of gene expression.

Conclusion

Sex-linked, sex-limited, and sex-influenced genes exhibit unique patterns of inheritance influenced by the genetic and hormonal makeup of individuals. Understanding these patterns is essential for studying genetic diseases, traits, and evolutionary biology.

References

Gupta, P. (2009). *Genetics*.
Kanakaraj, D. P. (2001). *A Textbook on Animal Genetics*.
Prakash, E. J. (1997). *Principles of Genetics and Genetic Engineering*.
Morgan, T.H. (1910). Sex-limited inheritance in Drosophila. *Science*, 32(812), 120–122.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/31/0625

MICROPLASTIC TOXICITY IN AQUAFEEDS AND WATER BODIES

Jitesh Singh*, Seerat Thind, Upjeet Kour Tulla and Prachee Keshavrao Kumbhare

M.F.Sc Scholar, Department of Aquaculture,
Guru Angad Dev Veterinary and Animal Sciences University,
Ludhiana, Punjab (141004), India
*Corresponding Email**:** Singhjitesh302@gmail.com

Abstract

A large quantity of harmful by-products from human activities is consistently present across various environments, contributing to pollution and ecological disruption (Shalu et al., 2025). Among these, microplastics (MPs) pose a significant environmental threat due to their persistence and widespread distribution. MPs, defined as plastic particles less than 5 mm in size, have become pervasive pollutants in aquatic environments due to the degradation of larger plastics and direct inputs like microbeads. Their presence in aquaculture systems, particularly through contaminated aquafeeds and water sources, poses significant risks to aquatic organisms and human health. Studies have documented MPs in various aquaculture species, with evidence of physiological and behavioral impacts, including oxidative stress and reproductive issues. Furthermore, MPs can act as vectors for other pollutants, exacerbating their toxicity. The accumulation of MPs in seafood raises concerns about food safety and necessitates comprehensive strategies to mitigate their presence in aquaculture.

Keywords: Microplastics, Aquafeeds, Aquaculture, Food Safety, Environmental Pollution

Introduction

Originating from the degradation of larger plastic debris or directly introduced as microbeads and fibers, MPs have been detected across marine, freshwater, and even atmospheric systems. The proliferation of plastic production—from 1.5 million tons in the 1950s to approximately 350 million tons by 2017—has exacerbated MP contamination, raising concerns about their impacts on ecosystems and human health. Aquatic organisms ingest MPs through water, food, or gill uptake, leading to accumulation in tissues and potential ecotoxicological effects such as oxidative stress, growth retardation, and behavioral abnormalities (Bhuyan, 2022). Given the rapid expansion of aquaculture to meet global food demands, understanding MP contamination in aquafeeds and farmed species is critical for ensuring food safety and ecosystem health.

Evidence of Microplastics in Fisheries and Aquaculture Products

MPs have been documented across marine and freshwater fisheries worldwide. The two most common methods for identifying microplastics are Fourier transform infrared spectroscopy and Raman micro-spectroscopy (Dubey et al., 2024). Studies report that between 20% and 70% of sampled wild-caught fish contain MPs in their gastrointestinal tracts. In marine environments, MPs have been detected in commercially important species, including fish, crabs, and shellfish, with evidence of trophic transfer up food webs. For instance, MPs ingested by planktivorous fish can be transferred to predators, such as tuna and swordfish (Romeo *et al*., 2015). Spatial variations are evident, with higher MP loads observed in species near urbanized or industrialized coasts (Peters and Bratton, 2016).

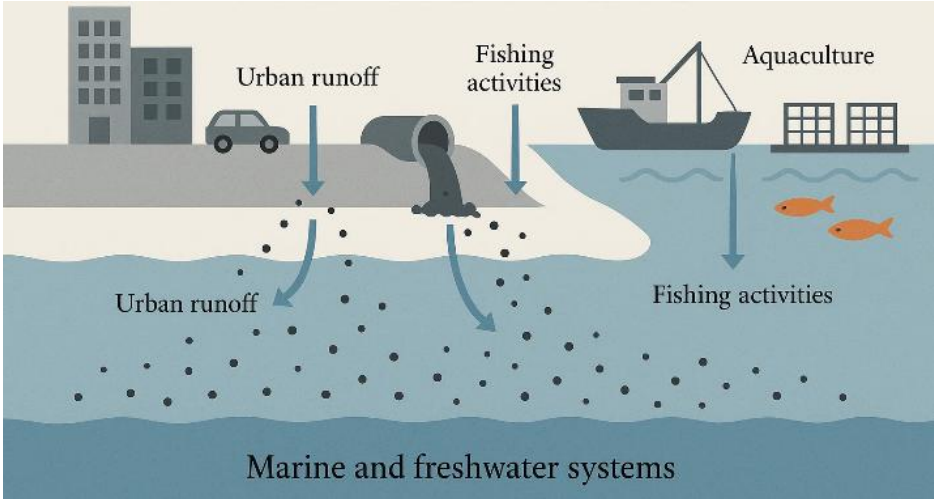


Fig-1: Sources and Pathways of Microplastics into Aquatic Ecosystems

Freshwater species are similarly affected; riverine and lake fish ingest MPs from fibers, fragments, and microbeads present in those waters. Importantly, MPs have been found not only in gastrointestinal tissues but also in the edible fillets of fish and shellfish destined for human consumption. A recent study detected MPs in 99% of seafood samples from U.S. markets, with shrimp and small forage fish showing the highest concentrations (Granek *et al.*, 2025).

Microplastics in Aquaculture Species

One of the areas of food production that is expanding the quickest in the world is aquaculture, which is essential to supplying the need for fish and shellfish protein (Vishal and Shalu, 2024a). MPs can enter into aquaculture from both their environment and feeds. Feed is essential in aquaculture, providing nutrients for fish growth and energy. Without adequate nutrition, larvae are more prone to poor growth, higher mortality rates, and susceptibility to diseases (Vishal and Shalu, 2025). Increasing demand has led to greater reliance on wild-sourced fishmeal and fish oil (Vishal and Shalu, 2024b). These ingredients can also introduce microplastics from marine pollution, posing risks of bioaccumulation, health issues, and ecological impacts. Also, Chitin, derived from crustacean exoskeletons and insect shells, enhances fish growth and immunity in aquafeeds (Suryawanshi et al., 2024). However, its sources may contain microplastics from marine pollution, potentially introducing contaminants that pose bioaccumulation and ecological risks.

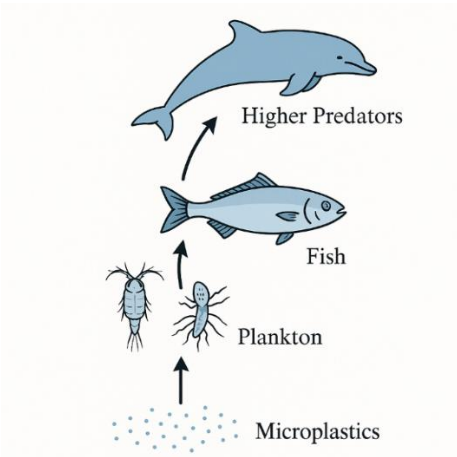


Fig-2: Trophic Transfer of Microplastics in the Food Web

Comparisons between wild and farmed seafood have yielded nuanced results. In some cases, wild and cultured individuals of the same species show similar MP loads, especially if the culture environment contains MPs. Depuration, the process of holding aquatic species in clean water to allow them to purge ingested particles, can effectively reduce MP content. A study found that a 93-hour depuration reduced MP counts in mussels by approximately 47% in wild mussels and 29% in farmed mussels (Birnstiel *et al*., 2019). In aquaculture systems, MP contamination can originate from contaminated water sources and aquafeeds. Recent research has revealed that commercial aquafeeds often carry MPs. Mohsen *et al*. (2024) reported the presence of MPs in various commercial aquafeeds, attributing contamination to both raw materials and manufacturing processes. Feeds for frogs and carnivorous fish, such as sea bass, had the highest MP levels, correlating with larger pellet sizes introducing more fragments. The majority of MPs in feed were microfibers, predominantly polypropylene, implicating feed processing and packaging materials as major contamination sources. Cultured fish in freshwater ponds are also exposed to MPs from their rearing environment. Studies of aquaculture ponds in various regions, including Asia, show MP contamination of both pond water and sediments, often with high levels near industrial or urban areas. In Bangladeshi fish ponds, MP concentrations in water reached tens of particles per liter, and sediments contained up to hundreds per kilogram, with higher contamination in ponds near intensive human activity (Hossain *et al*., 2023).

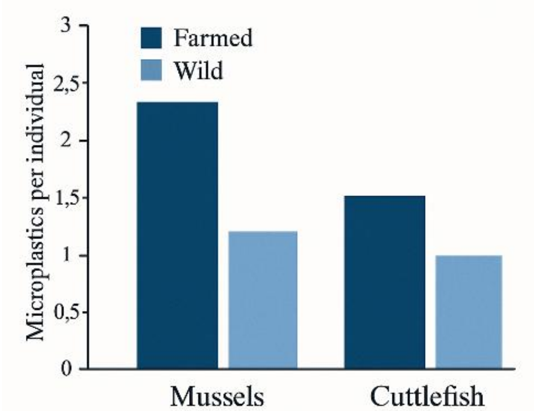


Fig-3: Comparative MPs Concentrations in Aquaculture vs. Wild Species

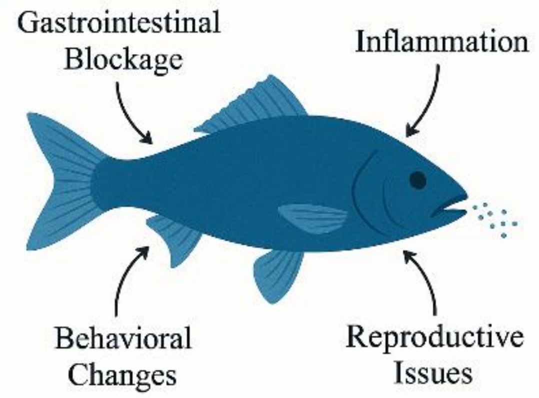


Fig-4: Physiological Effects of MPs on Aquatic Organisms

These data indicate that both marine and freshwater aquaculture species can accumulate MPs from their environment and feed.

Effects on Fish and Aquatic Organisms

Once ingested or inhaled, MPs can affect aquatic organisms at multiple biological levels. Digestive retention of MPs is a primary concern: many fish and invertebrates retain MPs in their gastrointestinal tract for days to weeks, causing physical blockages, false satiation, and reduced feeding. Laboratory experiments show that MPs can accumulate in fish GI tracts and even cause gut perforations or inflammation in severe cases. Metabolic and physiological impacts have been documented; chronic MP exposure has induced oxidative stress, evidenced by elevated reactive oxygen species and antioxidant enzyme activity in fish (Bhuyan, 2022). Behavioral changes have also been observed, such as reduced activity and altered prey response, likely linked to neurological or sensory effects of MPs and associated chemicals. Reproductive toxicity is another emerging concern: studies on model fish report disrupted gene expression in gonads and reduced fecundity after high MP exposure. Embryonic and larval development can be impaired, leading to delayed hatching, malformations, and lower survival (Lönnstedt and Eklöv, 2016). MPs can also translocate beyond the gut. Although the gastrointestinal tract and gills often contain the highest concentrations, evidence shows that very small MPs (<150 µm) or nanoplastics can cross intestinal barriers or gill membranes. Studies found that after ingestion, MPs mostly accumulate in fish guts and gills initially, but a fraction can enter the bloodstream and deposit in other organs like the liver or muscle (Hirt and Body-Malapel, 2020). Smaller MPs and nanoplastics pose a greater risk of systemic absorption, potentially reaching muscle, liver, or even crossing blood–brain or placental barriers in extreme cases. Beyond direct effects, MPs can act as vectors for pathogens and pollutants. Due to their high surface area and hydrophobic nature, MPs readily sorb persistent organic pollutants like PCBs or PAHs, heavy metals, and even pharmaceutical residues from water. Ingestion of such contaminated MPs could deliver these toxins into fish tissues. Additionally, biofilms on MPs can harbor pathogenic microbes, facilitating the transport of harmful bacteria and viruses across water bodies. The co-ingestion of plastic with adhered toxins or microbes means fish may suffer combined exposure, compounding health risks.

Implications for Human Consumption

Given the prevalence of MPs in seafood, humans are indeed ingesting these particles. Seafood consumption is a major route of MP exposure for humans. MP ingestion by humans occurs when consuming whole organisms, such as shellfish and small fish, with their gastrointestinal tracts intact, or even fillets, since some MPs can translocate into fish muscle. Current evidence suggests that the majority of ingested MPs pass through the human gut and are excreted. Larger particles (>150 µm) are unlikely to be absorbed into the human body. They tend to become embedded in the gut lining or trapped in mucus, possibly causing localized irritation or affecting gut microbiota composition (Hirt and Body-Malapel, 2020). Smaller MPs and nanoplastics, however, may be absorbed. Research indicates that particles under approximately 20–150 µm could cross the intestinal epithelium via uptake by M-cells or paracellular transport. Indeed, polystyrene micro- and nanoparticles fed to rodents have been found to penetrate intestinal tissue and distribute to lymph nodes, liver, and other organs. Another consideration is seafood packaging and handling as contamination sources. MPs in fish fillets or cleaned seafood might not only come from the ocean but also from processing. For instance, filleting fish on plastic cutting boards or storing seafood in plastic containers could introduce fibers and fragments. A study noted higher MP levels in processed store-bought fish compared to fish taken directly off a boat, hinting that handling and packaging added contamination (Granek *et al.*, 2025). As humans ingest MPs, potential health effects are a growing concern. MPs have been found in human tissues, including placentas and lungs, and a recent study found MPs in cardiac tissue with correlations to cardiovascular risk. Proposed risks include inflammation, oxidative stress, and disruption of gut microbiota (leading to dysbiosis). However, current knowledge on human health impacts is incomplete. There is a considerable gap in understanding the dose at which ingested MPs might cause systemic effects or toxicity in people. To date, no direct causative link between consuming MP-tainted seafood and specific human diseases has been confirmed, but the presence of plastic-associated chemicals, such as bisphenols, phthalates, and PFAS that leach from plastics, is of particular concern since many are known endocrine disruptors or carcinogens.

Seafood Security and Sustainability

Sustainability refers to the ability to meet present needs without compromising the ability of future generations to meet their own (Vishal et al., 2025). Microplastics, originating from degraded plastic waste, have infiltrated marine ecosystems globally. Their ingestion by fish and shellfish can lead to physical blockages, reduced feeding efficiency, and impaired growth and reproduction. Such physiological stressors diminish the fitness of aquatic organisms, potentially leading to decreased wild stock productivity over time. For instance, studies have shown that MPs can cause oxidative stress and immune system disruptions in fish, leading to increased mortality rates. In aquaculture settings, the problem is compounded. Microplastics can enter through contaminated water sources, feed, and equipment. Research indicates that aquafeeds often contain MPs, primarily due to contaminated raw materials and manufacturing processes. The ingestion of these particles by farmed species not only affects their health but also poses risks to human consumers.

Human Health Implications

The consumption of seafood contaminated with microplastics is a growing concern. MPs have been detected in various seafood products, including fish, shrimp, and mussels. Once ingested by humans, microplastics can accumulate in the gastrointestinal tract and potentially translocate to other organs. Studies have found MPs in human tissues, including the liver and kidneys, suggesting systemic exposure. Moreover, MPs can act as vectors for other harmful substances. They have the capacity to adsorb persistent organic pollutants and heavy metals from the environment, which can then be released into the human body upon ingestion. This co-exposure can lead to synergistic toxic effects, including endocrine disruption and carcinogenic outcomes.

Broader Environmental and Economic Consequences

Beyond health implications, microplastic pollution affects the broader ecosystem and economy. The decline in fish populations due to MP-induced stress can disrupt food webs and biodiversity. Economically, fisheries and aquaculture industries may suffer from reduced yields and increased costs associated with mitigation measures. Consumer confidence in seafood safety may also wane, impacting market demand.

Mitigation Strategies

Addressing microplastic pollution requires a multifaceted approach-

1. **Improved Waste Management**: Reducing plastic waste through recycling and proper disposal can limit the entry of MPs into aquatic environments.
2. **Aquaculture Best Practices**: Implementing filtration systems, using alternative materials for equipment, and ensuring clean feed sources can minimize MP contamination in aquaculture.
3. **Policy and Regulation**: Enacting policies that limit single-use plastics and promote sustainable practices can have a significant impact.
4. **Public Awareness and Education**: Informing consumers about the sources and risks of microplastic pollution can drive behavioral changes and support for environmental initiatives.

Conclusion

The infiltration of microplastics into aquaculture systems underscores a pressing environmental and public health challenge. Their presence in aquafeeds and aquatic environments not only affects the health and productivity of farmed species but also poses potential risks to human consumers through the food chain. Addressing this issue requires a multifaceted approach, including improving waste management practices, enhancing aquaculture protocols to minimize contamination, and implementing stringent regulations on plastic use. Continued research and public awareness are essential to develop effective mitigation strategies and ensure the sustainability and safety of aquaculture products.

References

Bhuyan, M. S. (2022). Microplastics in aquatic environments: Occurrence, effects, and potential solutions. *Environmental Science and Pollution Research*, 29(5), 12345–12356.

Birnstiel, S., Soares-Gomes, A., and da Gama, B. A. P. (2019). Depuration reduces microplastic content in wild and farmed mussels. *Marine Pollution Bulletin*, 140, 241–247.

Dubey, S., Honnananda, B. R., Tyagi, A., Vishal, And Jagpal. (2024). Occurrence And Effect of Microplastic in Marine Environment. International Journal of Progressive Research In Engineering Management and Science, 4(3), 907-911.

Granek, E. F., Brander, S. M., and Traylor, S. (2025). Microplastic contamination in seafood: A study of anthropogenic particles in marine species from the Pacific Northwest. *Frontiers in Toxicology*, 3, 123456.

Hirt, N., and Body-Malapel, M. (2020). Immunotoxicity and intestinal effects of nano- and microplastics: A review of the literature. *Particle and Fibre Toxicology*, 17(1), 57.

Hossain, M. S., Rahman, M. A., and Chowdhury, M. A. (2023). Microplastic contamination in aquaculture ponds in Bangladesh: A preliminary study. *Environmental Monitoring and Assessment*, 195(3), 456.

Lönnstedt, O. M., and Eklöv, P. (2016). Environmentally relevant concentrations of microplastic particles influence larval fish ecology. *Science*, 352(6290), 1213–1216.

Mohsen, M., Li, J., and Zhang, Y. (2024). Microplastic pollution in aquafeeds: Sources and implications for aquaculture. *Heliyon*, 10(2), e013401.

Peters, C. A., and Bratton, S. P. (2016). Urbanization is a major influence on microplastic ingestion by sunfish in the Brazos River Basin, Central Texas, USA. *Environmental Pollution*, 210, 380–387.

Romeo, T., Pietro, B., Pedà, C., Consoli, P., Andaloro, F., and Fossi, M. C. (2015). First evidence of presence of plastic debris in stomach of large pelagic fish in the Mediterranean Sea. *Marine Pollution Bulletin*, 95(1), 358–361.

Shalu, Shivkumar, Dubey, S., and Vishal**.** (2025). Recirculatory aquaculture systems (RAS). In S. S. Chinchorkar, P. Sial, S. C. Koujalagi, A. Prakash, I. Singh, and N. Kaur (Eds.), *Future perspectives in agriculture and allied disciplines* (1st ed., pp. 386–403). The Pustakalaya.

Suryawanshi, U., Vishal, And Shalu. (2024). Overview Of Industrial and Economical Uses of Chitin and Chitosan. *Agriculture And Food: E-Newsletter*, 6(11), 243-247.

Vishal And Shalu. (2024). Antinutritional Factors and Digestibility Challenges in Aquafeeds: A Review. *International Journal of Progressive Research in Engineering Management and Science*, 4(10), 924-928.

Vishal and Shalu. (2024). Role of probiotics and prebiotics in aquaculture nutrition: A review. *International Journal of Research Publication and Reviews*, 5(11), 1833-1838.

Vishal and Shalu. (2025). Impact of bio-enrichment on larval survival andgrowth performance. *Agri-India TODAY*, 5(5), 47-53.

Vishal, Shalu, Singh, J., and Dubey, S. (2025). Advances in fish harvesting technology forsustainable fisheries management. *Agri-India TODAY*, 5(5), 185-191.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 05/VI/32/0625

NANO UREA: INNOVATION OR HYPE?

Garvita Jaiswal[1], Simran Vats[2],
Aditya Kumar Giri[2] and Ankit Singh Bhadauria[3]

[1] M.Sc. Ag. (Hort.) Fruit Science, SAAST, Chhatrapati Shahu Ji Maharaj University, Kanpur
[2]M.Sc. Ag. (Hort.) Vegetable Science, SAAST, Chhatrapati Shahu Ji Maharaj University, Kanpur
[3]Assistant Professor, SAAST, Chhatrapati Shahu Ji Maharaj University, Kanpur
Corresponding Email: garvitajaiswal2@gmail.com

Abstract

Nano Urea represents a novel advancement in nitrogen fertilization, offering potential benefits for precision agriculture and sustainability. Introduced by IFFCO in 2021, this liquid formulation contains nitrogen in nanoparticle form (<100 nm) and is intended for foliar application. The article provides a detailed evaluation of Nano Urea, tracing its historical background, physicochemical characteristics, mode of application, efficiency comparisons, and its emerging relevance in horticultural practices. Compared to conventional urea, Nano Urea demonstrates improved Nitrogen Use Efficiency (up to 80%), reduced environmental losses, and user-friendly handling. However, due to its low nitrogen concentration, it cannot fully replace granular urea, particularly for soil-based nitrogen requirements. While early trials show encouraging responses in various crops, especially fruits and vegetables, further crop-specific and region-specific research is necessary. The article concludes that while Nano Urea holds promise as a supplementary nitrogen source, its widespread adoption should be guided by scientific validation and long-term environmental assessments.

Introduction

In the age of climate-smart agriculture and precision farming, the development of nano-based agrochemicals has marked a significant shift in input efficiency. Among these, *Nano Urea*—a product of nanotechnology applied to plant nutrition—has generated widespread discussion. Is it the long-awaited innovation to revolutionize nitrogen fertilization, or just another overhyped agri-input?

Historical Perspective: The Nitrogen Problem

Nitrogen (N) is a vital macronutrient required for plant growth, primarily absorbed in the form of nitrate (NO_3^-) or ammonium (NH_4^+). Traditional urea [$(NH_2)_2CO$], containing 46% nitrogen, has been the dominant nitrogenous fertilizer in India since the Green Revolution. However, the Nitrogen Use Efficiency (NUE) of conventional urea remains distressingly low, often 30–40%, with the rest lost through volatilization, leaching, denitrification, or surface runoff.

These inefficiencies contribute to soil acidification, groundwater contamination, eutrophication of water bodies, and increased greenhouse gas emissions (mainly nitrous oxide, N_2O). The need to enhance NUE without increasing the fertilizer input burden has led researchers toward nanotechnology-based solutions.

What is Nano Urea?

Nano Urea is a liquid fertilizer containing nitrogen particles at the nanoscale (<100 nm). Developed by the Indian Farmers Fertiliser Cooperative Limited (IFFCO) and officially launched in 2021, Nano Urea is claimed to improve nitrogen delivery to crops through foliar application. One 500 mL bottle of Nano Urea is promoted as an alternative to one 45 kg bag of conventional urea.

Physicochemical Properties:

- Nitrogen concentration: ~4% (w/v)
- Particle size: 20–50 nm
- Surface area: High, leading to enhanced absorption
- Mode of action: Absorbed through stomata, cuticles, and phloem translocation

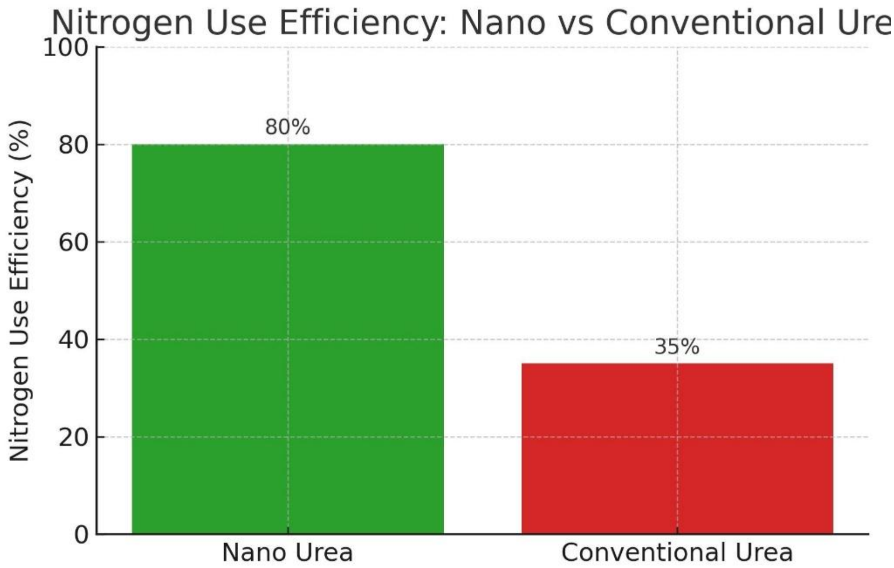
Mechanism of Action:

Nano-sized particles exhibit increased mobility and adhesion, allowing better stomatal penetration and subsequent translocation to the phloem and xylem. This facilitates targeted nitrogen release, minimizing losses and improving NUE.

Application Methods and Dosage

- Application Stage: Generally during the active vegetative stage or before flowering
- Dosage: 2–4 mL per liter of water
- Frequency: 2–3 sprays per cropping season
- Crops: Applicable to horticultural crops (fruits and vegetables), cereals, pulses, and oilseeds

Example in Horticulture: In mango (*Mangifera indica*), foliar application of Nano Urea during the pre-flowering and fruit development stages has shown better vegetative vigour and fruit set in preliminary trials.



Scientific Evidence and Field Trials

Though commercial adoption is rising, research is ongoing regarding its real-world effectiveness:

Positive Results:

- ICAR-Indian Agricultural Research Institute (IARI) trials on wheat and maize demonstrated an 8–10% increase in yield with a 25–50% reduction in conventional urea use.
- In brinjal (Solanum melongena), foliar Nano Urea application showed improved chlorophyll content and leaf area index (LAI).

Limitations:

- Nitrogen content (4%) is significantly lower than conventional urea (46%), meaning it cannot completely replace basal N requirements.

- Limited soil-N amendment: Nano Urea cannot contribute to soil nitrogen pool replenishment as effectively as granular urea.
- Regulatory ambiguity on long-term nano-material buildup in ecosystems.

Role in Precision and Sustainable Horticulture

With increasing emphasis on Integrated Nutrient Management (INM) and Good Agricultural Practices (GAPs), Nano Urea can act as a supplementary input in:

- High-value crops like capsicum, strawberry, and grape, where balanced nutrition is crucial.
- Protected cultivation systems such as polyhouses and greenhouses where nutrient delivery through fertigation and foliar spraying is controlled.
- Organic and residue-sensitive farming systems are looking to minimize salt buildup and runoff.

Challenges and Concerns

1. Over-reliance on foliar nutrition may neglect the need for a robust soil nutrient base.
2. Absence of independent peer-reviewed studies on crop-specific response curves.
3. Nano-toxicological risks to soil microbiota and pollinators remain understudied.
4. Farmer awareness and extension gaps in understanding correct dosage and timing.

Policy and Promotion

Nano Urea is central to India's policy of reducing urea subsidy burden (₹1.7 lakh crore in 2022–23) and achieving Atmanirbhar Bharat in fertilizers. Government agencies like IFFCO, Fertilizer Association of India (FAI), and Krishi Vigyan Kendra (KVKs) are promoting their use through field demonstrations and mobile vans.

Comparative Analysis: Nano Urea vs Conventional Urea

Parameter	Nano Urea	Conventional Urea
Nitrogen content	~4%	46%
Application mode	Foliar	Soil-based
Nitrogen use efficiency (NUE)	Up to 80%	30–40%
Environmental impact	Lower	High (N leaching, volatilization)
Storage & Handling	Easy, non-explosive	Needs secure storage
Price (approx.)	₹240–₹300/500 mL	₹276/45 kg (subsidized)

Prospects and Recommendations

- Integrative use with slow-release fertilizers and biofertilizers can create a holistic nutrient regime.
- More crop-specific studies on horticultural crops under varied agro-climatic conditions are urgently required.
- Nano Urea 2.0, with dual nutrient formulation (N + micronutrients), is under development and may enhance performance further.
- Need for standardization protocols and ecotoxicological assessments by agencies like FAO and ICAR.

Conclusion: Innovation with Caution

Nano Urea represents a paradigm shift in nutrient delivery and may become a cornerstone of climate-resilient agriculture. However, it is not a silver bullet. Its best utility lies in supplementing, not substituting, conventional fertilization—particularly in horticultural systems, where nutrient demand varies with phenological stages. Future deployment should be guided by scientific evidence, economic viability, and ecological safety.

References

IFFCO. (2021). *Nano Urea Product Launch and Technical Dossier*. Retrieved from: https://iffco.in

ICAR-IARI. (2022). *Evaluation of Nano Urea on wheat and maize under different agro-ecological zones*.

Fertilizer Association of India (FAI). (2023). *Fertilizer Statistics 2022–23*.

FAO. (2021). *Nanotechnologies in Agriculture: New Tools for Sustainable Development*.

Singh, R. K., & Mishra, A. (2022). "Nano Urea and its implication on nitrogen efficiency." *Journal of Plant Nutrition*, 45(6), 1001–1012.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/33/0625

THE ONE HEALTH APPROACH TO FISH, HUMAN AND ENVIRONMENTAL WELL-BEING

Santhiya. V[1]*, Kaviarasu. D[2], Saravanan. S[3] and Porselvan. S[4]

1,2,3,4 Department of Aquatic Animal Health Management,
Tamil Nadu Dr. J. Jayalalithaa Fisheries
University, Dr. M.G.R. Fisheries College and Research Institute, Ponneri- 601204
Corresponding Email: sant19082000@gmail.com

Abstract
The fisheries sector plays a vital role in global food security by providing nutrition and livelihoods to millions, especially in developing nations. However, the rapid expansion of aquaculture has resulted in public health, environmental, and food safety concerns. The misuse of antibiotics, poor biosecurity practices, zoonotic disease transmission, and environmental pollution contribute to significant public and environmental health risks. The One Health approach emphasizes the interconnectedness of human, animals, and environmental health and it offers a powerful framework to address these complex issues holistically. This article highlights the importance of One Health in aquaculture for building a resilient and sustainable fish farming industry that protects both human and environmental health.

Keywords : Zoonotic diseases, antimicrobial resistance, food safety hazards, aquaculture, environmental health

Introduction
The fisheries sector plays a crucial role in global food economy. It contributes significantly in addressing food security challenges. It serves as a key source of nutrition and livelihood for millions of people across the world, especially in developing countries. The rapid growth of aquaculture leads to poor farm management, antibiotic misuse, and environmental degradation. These can threaten fish, human and environmental health. Hence, there is an increasing need for health-conscious and environmentally responsible aquaculture practices. The One Health approach should be applied, as it is a powerful framework that links the health of human, animals, and the environment in a unified strategy for a safer and more sustainable future (Pradeepkiran, 2019).

One Health approach
One Health is a holistic approach that aims to maintain a sustainable balance between the health of human, animals, and the environment. This approach recognizes the deep interconnection among the health of human, animals, and the ecosystems they inhabit. By integrating efforts across these sectors, One Health enhances our ability to prevent, detect, and respond to health threats, thereby strengthening overall disease control and supporting global health resilience. One Health is promoted by global organizations like WHO, FAO, OIE, and UNEP. It seeks to tackle modern health threats such as zoonotic diseases and climate-induced disease outbreaks by bridging gaps between these sectors. Since farmed fish interacts with human and aquatic environments daily, this approach is essential (Bass *et al*., 2024).

Interconnected Health Threats and a unified approach
Health risks are increasing globally. These are driven by factors such as climate change, land-use alterations, unsustainable farming practices, globalization, and the trade of wildlife. These conditions help the pathogens to adapt and emerge in new forms, increasing the frequency and

severity of spread of diseases from animals to humans. However, the threat is not limited to human populations alone. Pathogens can also move in the opposite direction (from humans to animals), posing significant health risks to both domestic and wild species. No single sector can manage them alone; hence, a collaborative approach is required to tackle these complex and interconnected challenges.

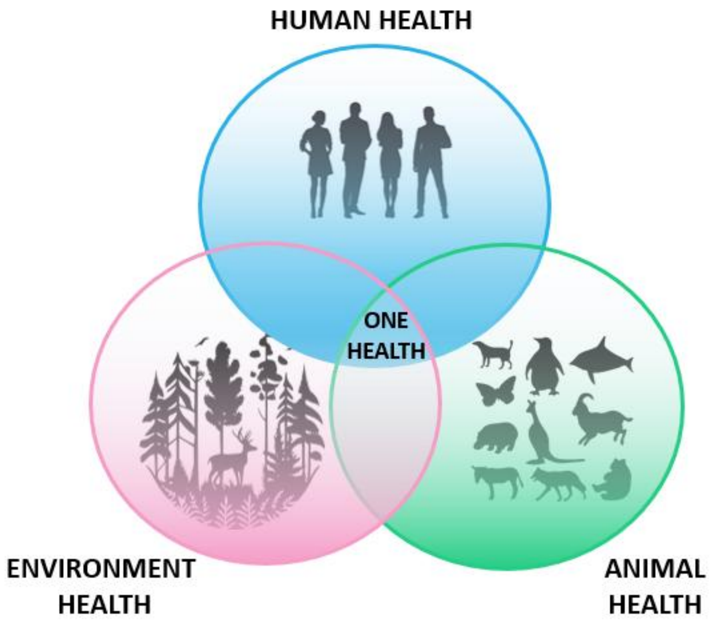


Figure: Interconnection of Animals, Human and Environment health

How fish health affects human health

a. Fish borne zoonotic diseases

Zoonotic diseases can be transmitted from aquatic animals to humans, which represents global public health concern. These diseases originating from fish and aquatic environments present significant challenges to the global aquaculture and fisheries industries.

Table: Zoonotic diseases from aquatic animals to humans

Type of Zoonotic Disease	Pathogens
Bacterial zoonotic diseases	Gram-positive bacteria: Mycobacteriaceae, Streptococcaceae and Erysipelothricaceae
	Gram-negative bacteria: Aeromonadaceae, Vibrionaceae, Pseudomonadaceae, Enterobacteriaceae and Hafniaceae
Parasitic zoonotic diseases	Cestodes (e.g., *Diphyllobothrium* spp.), trematodes (e.g., *Opisthorchis* spp.), nematodes (e.g., *Anisakis* spp.) and protozoa *Cryptosporidium* spp.
Fungal zoonotic diseases	Basidiobolomycosis and sporotrichosis

Transmission of zoonoses from aquatic animals to humans generally occurs through the consumption of raw or undercooked fish and seafood products. Therefore, adopting safe processing methods such as thorough cooking or freezing can significantly reduce the spread of zoonoses (Ziarati *et al*., 2022).

b. Antibiotic Use and Antimicrobial Resistance in Aquaculture

Aquaculture sector is expanding faster than any other animal production sector. This rapid development leads to questioning the safety and quality of aquatic food products. Regulations regarding antibiotic use in aquaculture are often inadequate, it varies significantly across countries and is poorly followed in several major aquaculture producing countries. Due to the lack of antibiotics specifically formulated for aquaculture, medications approved for other veterinary uses are frequently used. Such practices, especially the excessive and unregulated use of antibiotics contribute to the emergence of antimicrobial-resistant bacteria (AMRB) in aquatic environments, which may enter the food chain through fish intended for human consumption. The persistent presence of low level of antibiotics in water promotes the development and proliferation of resistant bacterial strains. It also facilitates horizontal gene transfer among aquatic bacteria, enhancing the spread of resistance traits. It is now clearly understood that antimicrobial resistance genes and resistant bacteria can move between aquatic systems, terrestrial livestock, and human environments. This poses serious risks to public health, animal health, and the integrity of aquatic ecosystems (Santos and Ramos, 2018).

c. Food Safety Hazards in Aquaculture

Fish are affordable and hence, they are considered a reliable food source. The muscle tissues of healthy fish are generally sterile. Nonetheless, several hazards such as biological, chemical, and environmental hazards can infiltrate the aquaculture supply chain at various stages. These food-borne risks, including infections, toxins, chemical residues, and heavy metals, may result from poor farming practices, environmental degradation, or cultural practices in certain regions. Ensuring food safety in aquaculture has thus become an urgent global priority (Vergis *et al*., 2021).

d. Environmental Impact of Aquaculture and Climate Change

The disposal of waste from food industries into the environment has become a major public health issue. In addition to common chemical substances such as antimicrobials, hormones, minerals, pesticides, vitamins, and pigments. The environment is heavily contaminated with persistent organic pollutants (POPs) like polychlorinated biphenyls (PCBs) and dioxins. These toxic compounds tend to bioaccumulate in animal-based food chains. Likewise, heavy metals such as lead, cadmium, and mercury can enter the food supply through contamination of water, air, and soil. Unsustainable aquaculture practices lead to organic pollution, eutrophication, and environmental degradation. Along with chemical pollutants, can reduce dissolved oxygen levels, degrade water quality, and disrupt aquatic habitats. These degraded conditions encourage harmful microbes, threatening aquatic life. Additionally, severe climate changes have led to rise in water temperatures and the expansion of oxygen-deficient zones damaging marine ecosystems. Poorly managed fish farms can harm rivers, lakes, and coastal zones. One Health balances both the farm and the ecosystem (Vergis *et al*., 2021).

Building a One Health Aquaculture System

Integrating fish health, human health, and environmental health into every stage of fish farming is essential. Regular surveillance and early disease diagnosis helps to detect infections before they spread from animals to humans. Farm-level biosecurity measures such as cleaning equipment and quarantining new fish, reduces spread of diseases significantly. Replacing antibiotics with vaccines and natural immunostimulants helps in combating antimicrobial resistance. Eco-friendly systems like bio floc and recirculating aquaculture systems (RAS) reduce water usage, pollution, and the need for chemical inputs. These systems turn waste into usable biomass and maintain clean environments. Educating farmers on best practices in fish health management can be carried out. Consumer awareness on safe fish handling and cooking can also reduce zoonotic disease transmission. These strategies promote a resilient aquaculture sector that safeguards food security and public health.

Conclusion

Fish farming is closely connected to the health of human, animals, and the environment. Improper management of fish farms lead to the spread of diseases from fish to humans, overuse of antibiotics, and pollution of our water and ecosystems. All these problems can seriously affect our health and safety around the world. Using the One Health approach means working together to keep fish healthy, provide safe and nutritious seafood for people, and take care of our water and environment. By using better methods such as keeping fish farms clean, using vaccines instead of too many antibiotics, switching to eco-friendly systems, and teaching farmers and the public, we can make fish farming safer and better for everyone. In the end, taking care of fish health also means taking care of our own health and the health of the environment.

References

Bass, D., Baron, S., Travers, A., Longshaw, M., & Haenen, O. (2025). One Health in Fish and Shellfish. *Bulletin of the European Association of Fish Pathologists*, *45*(1). DOI: https://doi.org/ 10.48045/001c.124752

Pradeepkiran, J. A. (2019). Aquaculture role in global food security with nutritional value: a review. *Translational Animal Science*, *3*(2), 903-910. DOI: https://doi.org/10.1093/tas/txz012

Santos, L., & Ramos, F. (2018). Antimicrobial resistance in aquaculture: Current knowledge and alternatives to tackle the problem. *International journal of antimicrobial agents*, *52*(2), 135-143. DOI: https://doi.org/10.1016/j.ijantimicag.2018.03.010

Vergis, J., Rawool, D. B., Malik, S. V. S., & Barbuddhe, S. B. (2021). Food safety in fisheries: Application of One Health approach. *Indian Journal of Medical Research*, *153*(3), 348-357. DOI: https://doi.org/ 10.4103/ijmr.IJMR_573_21

Ziarati, M., Zorriehzahra, M.J., Hassantabar, F., Mehrabi, Z., Dhawan, M., Sharun, K., Emran, T.B., Dhama, K., Chaicumpa, W., & Shamsi, S. (2022). Zoonotic diseases of fish and their prevention and control. *Veterinary Quarterly*, *42*(1), 95-118. DOI: https://doi.org/10.1080/01652176.2022.2080298

https://www.who.int/health-topics/one-health#tab=tab_1

https://www.woah.org/en/what-we-do/global-initiatives/one-health/

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 05/VI/34/0625

SAVING EVERY DROP: INNOVATIVE WAYS TO CONSERVE WATER ON FARMS

Arup Mondal and Sourakanti Sarkar*
Department of Soil and Water Engineering,
Bidhan Chandra Krishi Viswavidyalaya, Nadia (W.B.)-741252
Department of Agricultural Economics,
Bidhan Chandra Krishi Viswavidyalaya, Nadia (W.B.)-741252
*Corresponding Email-bckvcaesersarkar@gmail.com

Abstract
This article explores innovative and practical methods to conserve water in agriculture, a sector that consumes nearly 70% of the world's freshwater. With increasing pressure on water resources due to climate change and population growth, farmers are turning to smarter irrigation, rainwater harvesting, wastewater reuse, crop diversification, and digital technologies. Highlighting examples from India, Israel, Mexico, and Australia, it also emphasizes the role of supportive government schemes like PMKSY, Atal Jal, and MGNREGA in promoting sustainable farming. Traditional water conservation methods, integrated with modern tools, offer promising solutions for securing agriculture's future. Every drop saved on the farm ensures food, livelihood, and environmental sustainability.

Keywords : Water Conservation; Sustainable Agriculture; Drip Irrigation; Rainwater Harvesting; Indian Government Schemes

Introduction
Water is life, especially on farms. From growing crops to raising animals, almost every part of farming depends on a steady, reliable supply of water. But with growing populations, shifting weather patterns, and increasing demand, farmers around the world are facing a challenge: how to do more with less. Thankfully, creative minds and time-tested practices are working together to help conserve every precious drop.

Why Water Conservation Matters on Farms
Agriculture accounts for about 70% of global freshwater withdrawals, according to the Food and Agriculture Organization (FAO). That's a staggering amount, especially in areas where water is already scarce. In India, around 90% of total water use goes toward agriculture, highlighting the critical need for efficiency.

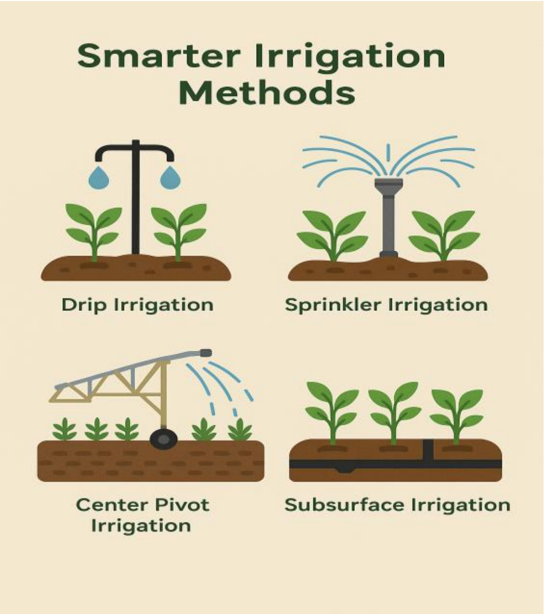
In some regions, over-irrigation has led to rivers running dry, underground water tables dropping, and soil becoming salty and infertile. When water is wasted, it's not just a resource being lost—it's food, livelihoods, and even future generations at risk.

That's why water conservation on farms isn't just an environmental concern—it's an economic and social one, too. Fortunately, a mix of smart technologies, traditional knowledge, and community efforts is helping farmers adapt.

Smarter Irrigation Methods
One of the biggest changes in water use on farms has come through better irrigation practices. Traditional flood irrigation—where fields are flooded with water—is often wasteful. Much of the

water evaporates or runs off before it can be used by plants. Modern systems are much more efficient.

Drip Irrigation is one of the most effective methods. It delivers water slowly and directly to plant roots through a system of pipes and emitters. This minimizes waste and helps plants grow better. In India, government support for drip irrigation has helped farmers in dry regions like Maharashtra grow crops like pomegranates and cotton with far less water than before.



➡ According to a 2022 report by the Ministry of Agriculture, drip irrigation can lead to 30–70% water savings and 20–90% yield increases depending on the crop.

In Telangana, the Mission Bhagiratha project has helped provide piped water supply and promoted the use of efficient irrigation techniques. Similarly, the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) encourages micro-irrigation across the country, making drip and sprinkler systems more accessible to small-scale farmers.

➡ Under PMKSY, more than 13 million hectares have been brought under micro-irrigation systems between 2015 and 2023.

Sprinkler Systems also help reduce water waste, especially when they are designed to match crop needs and weather patterns. These systems can be set on timers or even connected to sensors that check soil moisture and weather forecasts.

Collecting and Storing Rainwater

Rain doesn't always fall when or where it's needed. But when it does come, smart farmers know how to catch it. Rainwater harvesting involves collecting rainwater from roofs or fields and storing it for future use.

In parts of Kenya, farmers have built small ponds or lined reservoirs that collect rain during the wet season. They then use this stored water to irrigate crops during dry spells. In Australia, many farms use large tanks to capture rainwater from rooftops, helping them stay productive even during droughts.

In Rajasthan, India, traditional johads—small earthen check dams—have been revived by communities to collect and store rainwater. These simple structures have transformed once-parched villages by replenishing groundwater and making agriculture viable again.

➡ A study by the Centre for Science and Environment (CSE) showed that well-restored johads can increase groundwater levels by up to 6 meters in nearby wells.

Reusing and Recycling Water

Not all water has to be fresh to be useful. Greywater—lightly used water from homes or processing plants—can often be reused for irrigation after simple treatment. In Israel, more than 85% of wastewater is treated and reused, much of it on farms. This has helped the country thrive agriculturally in one of the driest regions on Earth.

In Tamil Nadu, India, several sugar factories have begun treating and reusing their wastewater for irrigating nearby fields. This not only conserves freshwater but also supports local farmers with a steady water supply.

➡ Reusing treated wastewater in agriculture can reduce demand for freshwater by 20–30%, depending on the sector.

Even water from food processing—like washing fruits or dairy waste—can be cleaned and used to water fields or clean equipment. This kind of recycling reduces demand on freshwater supplies.

Choosing the Right Crops

Sometimes, saving water means changing what we grow. Some crops need a lot more water than others. By selecting drought-tolerant or native plants, farmers can use water more wisely.

In parts of California, where water shortages are common, some farmers have replaced thirsty crops like alfalfa and rice with olives, grapes, or even cactus pears—plants that thrive in dry conditions. These changes not only save water but often open up new markets for farmers.

In India, agricultural scientists have promoted the cultivation of millets, which require significantly less water than rice or wheat. States like Karnataka and Odisha are encouraging farmers to shift to these resilient grains through subsidies and awareness campaigns.

➡ Millets use up to 70% less water than paddy and grow well in arid zones with annual rainfall of 300–500 mm.

Using Technology Wisely

New tools are making it easier than ever to know when and how much to water. Soil moisture sensors can tell a farmer exactly how dry the soil is, so they don't water more than necessary. Weather stations and satellite images help predict rain, so irrigation can be adjusted.

In Brazil, some farms use drone technology to monitor crop health and identify dry spots. This lets them target irrigation and avoid overwatering. Smartphone apps also allow farmers to control irrigation systems remotely, saving time and water.

In India, mobile apps like Kisan Suvidha and Farmonaut help farmers access weather forecasts, soil moisture levels, and crop advisories. These digital tools are empowering even smallholders to make smarter decisions about water use.

➡ Studies show that sensor-based irrigation can save 20–40% more water than manual methods.

Community and Policy Support

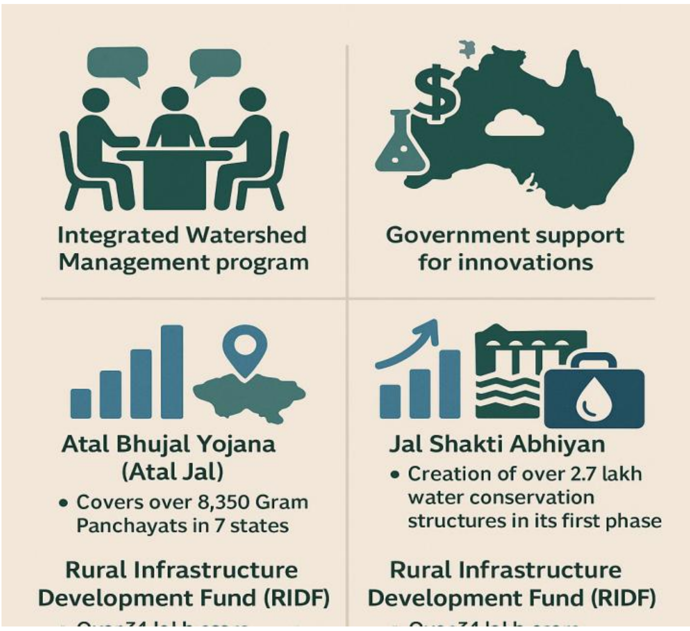
Water conservation isn't just about individual farmers—it's also about communities and governments working together. In Mexico, the "Manejo Integrado de Cuencas" (Integrated Watershed Management) program brings together farmers, scientists, and local officials to plan water use across whole regions.

Government programs that offer incentives for water-saving equipment or training can make a huge difference. In Australia, the government has supported water-saving innovations with funding and research partnerships, helping transform the country's water management approach.

India's Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) has supported the creation of water harvesting and conservation structures like check dams and farm ponds, particularly in water-scarce regions. These efforts not only conserve water but also provide employment and build resilience.

Some additional Indian government schemes supporting water conservation on farms include:

- Atal Bhujal Yojana (Atal Jal): A central scheme focused on community-led groundwater management, particularly in water-stressed regions. It promotes sustainable water use practices and awareness at the grassroots level.



- Covers over 8,350 Gram Panchayats in 7 states.
- National Mission for Sustainable Agriculture (NMSA): Part of the National Action Plan on Climate Change, this mission promotes climate-resilient farming, efficient water use, and integrated farming systems.
- Supports technologies like precision irrigation and water harvesting structures.
- Jal Shakti Abhiyan: A time-bound, mission-mode campaign that promotes water conservation and rainwater harvesting through active citizen participation, particularly during monsoon season.
- In its first phase, the campaign led to the creation of over 2.7 lakh water conservation structures.
- Rural Infrastructure Development Fund (RIDF): Managed by NABARD, this fund supports states in creating irrigation and rural water conservation infrastructure including watershed development.
- Over ₹1 lakh crore allocated since inception for irrigation-related projects.

Traditional Wisdom

Before modern technologies, farmers around the world developed their own ways of saving water. Many of these practices are still valuable today.

In Andean regions of South America, ancient stone-lined canals called "amunas" channel rainwater into the ground to refill underground water supplies. In Morocco, farmers use terracing and small earth dams to slow down rainwater and give it time to soak into the soil.

In India, age-old water systems like stepwells in Gujarat and tank irrigation in Tamil Nadu have long helped communities manage water. Reviving and maintaining these systems can play a crucial role in local water conservation efforts.

These traditional methods often work well with new technologies, combining the best of old and new.

Conclusion : Every Drop Counts

Water is one of farming's most precious resources. As the world faces growing pressure on water supplies, conserving every drop becomes essential. Fortunately, farmers are not alone in this effort. With the help of smart tools, supportive policies, and centuries of wisdom, they are finding ways to grow food more sustainably.

From the deserts of Israel to the farms of California, from Kenyan hills to Indian plains, the story is the same: innovation and care can turn challenge into opportunity. By saving water, we're not just helping farmers—we're securing our future.

By embracing both high-tech solutions and age-old practices, the farming world is proving that sustainable agriculture is not only possible but already underway. Every drop saved today is a seed for tomorrow.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/35/0625

POSTHARVEST PHYSIOLOGY OF CUT FLOWERS

Nalanda Acharya

Research Scholar, Department of Pomology and Postharvest Technology,
Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal-736165.
*Corresponding Email: nalandaacharya2018@gmail.com

Introduction

Cut flowers have a limited lifespan due to their transient nature and many stressors. Signs of floral senescence include decreased water intake, depletion of stored carbohydrates, and increases in ethylene production and respiratory activity. floral preservative solutions, ethylene action inhibitors, growth regulators, temperature management, and floral dehydration are just a few of the many methods available to prolong flower preservation. By either enhancing water balance and energy or postponing senescence through decreases in ethylene production, sucrose can be added to pulse solutions or used as a component of vase solutions to prolong the vase life of flowers. Some ethylene-sensitive flowers have their vase life extended by ethylene production and activity inhibitors. The high respiratory activity of flowers may exhaust the tissues' meager stores of carbohydrates. Lower temperatures significantly lessen the generation and effect of ethylene as well as the concentration of carbon dioxide. However, because of the severe development of tissue discoloration, chilling-sensitive flowers—like bird-of-paradise, heliconia, orchid, and ginger—cannot be kept below 10 to 13°C.

Water relations

Water deficit, which is mostly brought on by ongoing decreases in water intake, is directly linked to the wilting and senescence of petals in many flower species. A number of things, like air embolism, pectin and phenol deposition, or xylem obstruction by microbes, can prevent the blooms from absorbing water (Jędrzejuk et al., 2012). Longevity reduction in roses and carnations was also closely linked to the cut flower's ability to absorb water. For example, after ten days at room temperature, Van Doorn et al. (1995) discovered that the xylem of these flowers contained Pseudomonas spp., *Acinetobacter calcoaceticus*, and Alcaligenes sp. bacteria. These bacteria impeded water uptake and decreased the flowers' longevity inversely with increases in bacterial populations.

Respiration

Because they lack long-term storage organs, flowers often have higher respiration rates than other horticultural products, which could result in the depletion of carbohydrates. Higher rates of transpiration as well as the formation and action of ethylene are among the other harmful impacts. For most fruits and vegetables, the temperature coefficient (Q10) is near two; but, in lower temperatures, it may be as high as eight (Wills et al., 1998). By using inhibitors of its effect, especially silver thiosulfate (STS), which functions as a lasting inhibitor of the ethylene action, the respiration of ethylene-sensitive flowers can be decreased.

Growth regulators

Horticultural products' ethylene may shorten the lifespan of cut flowers or cause physiological problems such petal withering, senescence, abscission, epinasty, and chlorophyll depletion in leaves when they are being transported or stored (De Martinis et al., 2015). The sensitivity of the flower, which differs between species and cultivars, is correlated with the size of these reactions (Scariot et al., 2014; Costa and Finger, 2016). High ethylene sensitivity flower species exhibit physiological reactions at lower concentrations, typically 0.1–1 µl L-1 of air after 6–12 hours of exposure.

Gibberellin

Although gibberellin GA3 has been utilized extensively as an antagonist to the ethylene action in ornamental plants, its application has had effects other than lowering the rates of bloom senescence. By preventing senescence-related alterations in cell membrane permeability and protein degradation, roses sprayed with 1-mM GA3 inhibited the development of postharvest illnesses brought on by Botrytis cinerea (Shaul et al., 1995). According to other research, GA3 controls the function of abscisic acid (ABA) in gladiolus cell membrane maintenance and flower opening (Kumar et al., 2014; Costa et al., 2016).

Abscisic acid

As seen in carnations, ABA has been identified as a signal molecule that initiates leaf and floral senescence (Rubinstein, 2000). According to the authors, ABA is crucial for signal transduction processes that underlie daylily petals' planned cell death. According to Pompodakis et al. (2004), ABA's impact on rose blossom lifetime was pH-dependent. In this investigation, adding 10-5 M ABA at pH 6 induced stomatal closure with or without 1 mg L-1 AgNO3, extending the vase life.

Cytokinin

Another hormone that has been used into conservative solutions for cut flowers is cytokinin. For example, depending primarily on the species or cultivar under study, benzyl adenine (BA), a synthetic cytokinin of the generation, has shown varying effects on cut flowers after harvest. Additionally, BA increased the vase life of *Heliconia chartacea*, *Anthurium andraeanum*, *Heliconia psittacorum*, and *Alpinia purpurata* flowers by 1.5 to 2.5 times.

Carbohydrates

The flowers' extreme perishability necessitates the development and application of methods that enhance their durability, preserving the product's qualities and lowering postharvest losses. The use of preservative solutions is an alternative to avoid such effects, and the majority of them contain carbohydrates, typically sucrose, in their composition. The primary distinction between them depends on the amount of carbs added to each solution. Sugars are typically delivered by pulse treatment or as ingredients in vase solutions.

Conclusions

Cut flowers are an important component of the horticultural industry and are greatly regarded for their ornamental appeal across the globe. Their visual attractiveness and ornamental versatility make them a popular choice for numerous occasions, including weddings, festivities, and interior décor. The morphological characteristics of cut flowers, such as color, size, form, and freshness, as well as their longevity—the length of time these desirable characteristics are retained after harvest—are the key factors used to evaluate their overall quality. Shelf life is one of the most important of them since it has a direct impact on cut flower sales and consumer choice. A longer shelf life increases the flowers' market potential by ensuring that they stay fresh and aesthetically pleasing throughout storage, transit, and display. The postharvest durability and quality of cut flowers are substantially determined by the rate of senescence—the natural aging and breakdown process of plant tissues. A number of external and internal elements are crucial in controlling this process. Handling procedures, environmental factors, plant hormone activity, glucose availability, and water balance in the floral tissues are important examples of these. Senescence can be accelerated by inappropriate handling, for example, which might result in stress or bodily harm. The freshness of flowers can also be adversely affected by unfavorable climatic conditions including high temperatures, low humidity, or insufficient light. Senescence is significantly impacted by plant hormones, including cytokinins and ethylene. In many flower species, ethylene speeds up aging, although cytokinins can slow it down. Depletion of carbohydrates can cause early flower degeneration since they are an energy supply required to sustain cellular processes. Since water stress can result in wilting and diminished aesthetic appeal, proper water relations are particularly crucial. Numerous postharvest technologies and methods have been developed to control senescence-related factors in order to address these issues. These include the use of floral preservatives, advances in packaging, hormone-modulating treatments, and the regulation of temperature and humidity. Such technologies are being developed and used in an effort to prolong the vase life of cut flowers, maintain their quality, and eventually increase their marketability and financial return for both producers and merchants.

References

Costa, L. C., Araujo, F. F., Lima, P. C. C., Pereira, A. M., & Finger, F. L. (2016). Action of abscisic and gibberellic acids on senescence of cut gladiolus flowers. *Bragantia*, *75*(4), 377–385. https://doi.org/10.1590/1678-4499.361

De Martinis, D., Koyama, T., & Chang, C. (2015). Ethylene is all around. *Frontiers in Plant Science*, *6*, 76. https://doi.org/10.3389/fpls.2015.00076

Jędrzejuk, A. J., Rochala, J., Zakrzewski, J., & Rabiza-Świder. (2012). Identification of xylem occlusions occurring in cut clematis (Clematis L., fam. Ranunculaceae Juss.) stems during their vase life. *Scientific World Journal*, *2012*, 1–12. https://doi.org/10.1100/2012/749281

Kumar, M., Singh, V. P., Arora, A., & Singh, N. (2014). The role of abscisic acid (ABA) in ethylene insensitive Gladiolus (Gladiolus grandiflora Hort.) flower senescence. *Acta Plant Physiology*, *36*, 151–159. https://doi.org/10.1007/s11738-013-1395-6

Pompodakis, N. E., Joyce, D. C., Terry, L. A., & Lydakis, D. E. (2004). Effects of vase solution pH and abscisic acid on the longevity of cut 'Baccara' roses. *Journal of Horticultural Science and Biotechnology*, *79*(5), 828–832. https://doi.org/10.1080/14620316.2004.11511850

Rubinstein, B. (2000). Regulation of cell death in flower petals. *Plant Molecular Biology*, *44*, 303–318. https://doi.org/10.1023/a:1026540524990

Scariot, V., Paradiso, R., Rogers, H., & De Pascale, S. (2014). Ethylene control in cut flowers: Classical and innovative approaches. *Postharvest Biology and Technology*, *97*, 83–92. https://doi.org/10.1016/j.postharvbio.2014.06.010

Shaul, O., Elad, Y., & Zieslin, N. (1995). Suppression of Botrytis blight in cut rose flowers with gibberellic acid: Effects of postharvest timing of the gibberellin treatment, conidial inoculation and storage period. *Postharvest Biology and Technology*, *6*(3–4), 331–339. http://doi.org/10.1016/0925-5214(95)00008-T

Van Doorn, W. G., Witte, Y., & Harkema, H. (1995). Effects of high number of exogenous bacteria on the water relations and longevity of cut carnation flowers. *Postharvest Biology and Technology*, *6*(1–2), 111–119. https://doi.org/10.1016/0925-5214(94)00043-R

Wills, R., McGlasson, B., Graham, D., & Joyce, D. (1998). *Postharvest: An introduction to the physiology and handling of fruit, vegetables and ornamentals* (4th ed.). Wallingford: CABI

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/36/0625

PROCESSED FOOD PRODUCTS: BUSTING THE MYTHS WITH FACTS

Anshu Sharma

Scientist, Department of Food Science and Technology,
Dr YS Parmar University of Horticulture and Forestry,
Nauni, Solan, HP, 173 230, INDIA
*Corresponding Email: anshufst1989@gmail.com

Abstract

Awareness in consumers regarding nutrition is an important way in handling misguidance, wrong information and helps in promoting right processed food choices. This article aimed to impart knowledge of different types of processed food products and busting perceptions of today's population pertaining to a huge list of myths of processed food products along with substantial facts. It was concluded from literature, despite the health consciousness of today's consumer, there are still many food myths related to processed food products which need to be mitigated, through imparting the proper information, in order to generate balanced, healthy and right kind of proceed food choices in today's consumer's diet.

Key words: Processed Food, Health, Balanced, Right Food Choices, Myths, Facts

Introduction

Food is a basic necessity of human beings. Food plays an important role in the promotion of good health and also helps in prevention of many diseases. Recently, bad choices of food products along with poor life style have led to occurrence of many alarming diseases like cardiovascular diseases, cancer, tumours, and type 2 diabetes. Consumption of food has the main purpose of satisfying hunger of consumer but other factors like quantity of food, frequency of intake and choices of processed food product determine the end result of its effect on human body in long run (Florença *et al*., 2021).

Processed food

According to the U.S. Department of Agriculture, processed food is any altered fruit, vegetable, or food item, including cleaning, dehydrating, heating, juicing, or freezing, apart from raw agricultural produce. Therefore, frozen horticultural commodities, bread, and dairy products like yoghurt, all are considered as processed foods. And, while few of processed foods may be changed heavily than others, all processed foods start from their natural source i.e. plant or animal. Processed food is classified into four groups depending upon the purpose and extent of the processing treatment applied on. Following are four different groups of processed foods which have been classified by NOVA classification system:

1. **Minimally Processed Foods**: These are natural foods without addition of taste enhancers and additives. They are processed at minimal level without alteration of their originality. For example, cut fruits and vegetables, fresh fruit pulp/juice, plain yoghurt, plain milk *etc*.
2. **Processed Culinary Constituents**: Food items which are processed by application of various treatments like pressing, milling, refining, *etc*. For example, edible oils (cold pressed & refined oils), butter, salt, cane sugar and molasses, honey and maple syrup, *etc.*

3. **Processed Food Products**: Food items prepared by adding taste enhancers like sugar, oil or salt to make simple food products with enhanced storage life or enhanced flavour and other sensory attributes. For example, salt or sugar sprinkled nuts, smoked meats, canned fruits and vegetables, freshly made bread, *etc*.
4. **Ultraprocessed Food Products**: Food products prepared in industries with the inclusion of many ingredients like additives to enhance the flavour and storage life of the end products. Hydrolyzed proteins, soy protein isolates, high fructose syrup of corn, maltodextrin, flavour enhancers, non-sugary sweetening agents, stabilizers, bulking agents, anticaking or anti-bulking agents are those. Bread rolls, cake, cookies, breakfast ready to eat cereal products, instant ready to eat soups, frozen burgers and breads, tofu, flavoured yogurts, ready-to-heat meals or frozen meals, colds sugary carbonated drinks and confectionary products like candies, packed sweets, snack items, *etc*.

Myths about processed food products

Processed food is mostly thought to be of inferior quality to unprocessed food. Because packaged food item may contain many additives such as artificial colouring agents, flavouring agents, or other chemical preservatives. However, the quality of processed food product varies widely depending on the source and the method of processing. Few of important myths along with facts are mentioned below:

1. There is a very common myth that all the processed food products are nutritionally empty and also impart negative effects on human health. However, many processing methods are used to increase the storage life, to preserve food products or to enhance their nutritional value along with desirable sensory attributes such as enriching or fortifying food products with nutrients like proteins, vitamins, minerals, iodine, *etc.* to prevent certain deficiencies in the human system (Papanikolaou *et al*., 2021). Many processed and ultra-processed foods have important nutrients which are generally overlooked in our daily diet such as dietary fibre. Moreover, processing methods (thermal & non thermal treatments) like mechanical drying, freeze drying, spray drying, pasteurization, irradiation, high pressure processing, *etc*. can prevent growth of pathogens, extend the storage life and also improve flavour and texture, making food products more convenient to the end users.
2. It is believed that fresh is always best. But the fact is frozen horticultural commodities are packed at their optimum mature or ripe stage and can retain higher nutrients than fresh fruits and vegetables. Many canned fruits and vegetables can retain more nutrients than raw ones. Heat treatment can impact heat sensitive nutrients but still there are studies which have shown better sensory attributes of canned fruits and vegetables than raw ones. For example, canned tomatoes may contain more lycopene than fresh tomatoes (Bouzari *et al*., 2015).
3. It is believed that healthy dietary life style is quite expensive in terms of processed foods. But the fact is there are quite affordable nutritious foods, such as canned and frozen fruits and vegetables, pasta, breakfast cereals, eggs, flavoured yoghurts, salty nuts, and dried fruits and vegetables in the market.
4. It is said that cutting all processed foods from food supply is safe for health. Some people believe that removing processed foods especially ultra proceed food products (UPFs) from our diet is the most effective mean to prevent diseases. However, as per reports of Mattes, “Removing UPFs from the diet will increase foodborne illness,” since preservatives and food

additives make a food product 'ultraprocessed.' As such, today's busier households will be adversely affected since food items will be costlier and lesser convenient," They also reported that removing ultra processed food products will also increase the food waste.

5. There is a myth that a gluten-free diet is healthier for every individual. Gluten is a protein which is found in the grains like wheat, barley, and oats. There is no evident reason to remove gluten from diet, unless person can not tolerate gluten or diagnosed with the celiac disease. If one is sensitive to gluten, one is advised to add gluten-free grain products which are made up of gluten free grains like corn, millet, quinoa and rice.

Identification and role of right kind of processed foods in modern diets:

Consumer's demand for convenience has increased the consumption of ultra-processed food products, has made them a major component of today's food diet. Many energy-dense food products generally contain high levels of saturated fats and carbohydrates such as *vanspati ghee,* palm oil, added cane sugars, maltodextrins as well as sodium along with salts. Clever marketing skills include the use of popular punch lines, endorsements, celebrities and giveaways are greatly influencing dietary choices of our youth, especially among children and teenagers. Various reports have connected the consumption of many ultra proceed food products to increase the risk of obesity, metabolic syndrome, high blood pressure, diabetes, cancer, cardiovascular diseases, and even depression. However, all processed food products are not harmful. Identification of processed and ultra-processed food products solely from the food labels can be challenging, as particular processing techniques are generally not disclosed. However, knowing some basic concepts of development of food products and processing can help the consumer. It is always advisable to read food labels, having a bit more awareness and ability to decode food ingredients of packed food products especially of those which are quite high in energy or glycaemic index due to refined carbohydrates, unhealthy saturated fats, sugars, salt, sodium but low in proteins, vitamins, minerals and fibre.

Conclusion

It is always very crucial to inculcate the right choices in identifying and choosing the right kind of processed and ultra-processed food products. Many processed food products can be eaten safely and even can be used to avoid certain nutritional deficiencies. But still the association between many ultra processed food products and their negative health effects can not be neglected. Encouraging the consumption of enriched, fortified, thermally or non thermally processed or preservative free food products is essential for promoting health and ultimately better picture of food processing sector among common population.

References

Bouzari, A., Holstege, D., & Barrett, D. M. (2015). Vitamin retention in eight fruits and vegetables: A comparison of refrigerated and frozen storage. *Journal of agricultural and food chemistry*, *63*(3), 957-962. doi:10.1021/jf5058793.

Florença, S. G., Ferreira, M., Lacerda, I., & Maia, A. (2021). Food myths or food facts? Study about perceptions and knowledge in a Portuguese sample. *Foods*, *10*(11), 2746. doi:10.3390/foods10112746.

Papanikolaou, Y., & Fulgoni, V. L. I. (2021). The role of fortified and enriched refined grains in the US dietary pattern: a NHANES 2009–2016 modelling analysis to examine nutrient adequacy. *Frontiers in Nutrition*, *8*, 655464. doi:10.3389/fnut.2021.655464.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 05/VI/37/0625

SEEDS OF HOPE: A NEW ERA OF CLIMATE-READY AGRICULTURE IN INDIA

Adrita Dam[1] and Partha Mondal[2*]

[1]Division of Agricultural Economics, ICAR-IARI, New Delhi-110012
[*2]Dept. of Ag. Biochemistry, BCKV, W.B.-741252
*Corresponding Email: parthamondalgoura@gmail.com

Abstract
Climate change is transforming Indian agriculture, as increasing temperatures, postponed monsoons, recurrent droughts, floods, and insect infestations have become prevalent. More over 50% of the labour force depends on agriculture, with small and marginal farmers prevailing. Conventional agricultural methods are inadequate, resulting in a covert transformation towards climate-resilient crop types. The Honourable Prime Minister of India inaugurated 109 high-yielding, climate-resilient, and biofortified crop varieties at the Indian Agricultural Research Institute (IARI) in New Delhi on in 2024. Along with this the recent development of genome edited rive varieties by ICAR also create a significant milestone. These cultivars aim to provide improved yields, superior nutrition, and increased resilience to climatic challenges, representing a crucial advancement in fortifying India's enduring plan for sustainable and resilient agriculture.

Keywords : Climate resilience, Climate change, Abiotic stress, crop varieties

Introduction

Climate change is reshaping Indian agriculture, with rising temperatures, delayed monsoons, frequent droughts, floods, and pest outbreaks becoming common. Over 50% of the workforce relies on agriculture, and small and marginal farmers dominate. Traditional farming practices are insufficient, leading to a silent revolution in climate-resilient crop varieties. The Honourable Prime Minister launched 109 high-yielding, climate-resilient, and biofortified crop varieties at the Indian Agricultural Research Institute (IARI) in New Delhi (PIB,2024). These varieties are designed to deliver better yields, enhanced nutrition, and greater tolerance to climate stresses. In 2025, India became the first country to develop two genome-edited rice varieties, ensuring higher production, climate adaptability, and water conservation. These initiatives strengthen India's long-term strategy for sustainable and resilient farming.

The Growing Need for Resilient Varieties

Climate variability has led to a rise in crop failures, increased pest incidence, and mounting financial losses for farmers.

- Over 60% of India’s net sown area is rainfed, and thus vulnerable to rainfall fluctuations.
- Wheat yields are declining due to increasing temperature during grain filling stages.
- Rice production faces submergence risks in flood-prone areas of Eastern India.
- Salinity in coastal regions threatens the productivity of otherwise fertile land.

Climate-resilient crop varieties are an adaptive solution. They are bred to perform under stress conditions without compromising on quality or yield. Many also mature early, saving irrigation and allowing for timely sowing of the next crop. These new seeds, when made accessible to farmers, reduce input dependency and provide insurance against unpredictable weather.

Uniqueness of 109 varieties

According to ICAR, these newly released varieties belong to 61 different crops (ICAR 2024), including (Fig.-1):

- ✓ 34 field crops: cereals, pulses, oilseeds, cotton, sugarcane, and forage.
- ✓ 27 horticultural crops: fruits, vegetables, tuber crops, plantation crops, spices, flowers, and medicinal plants.

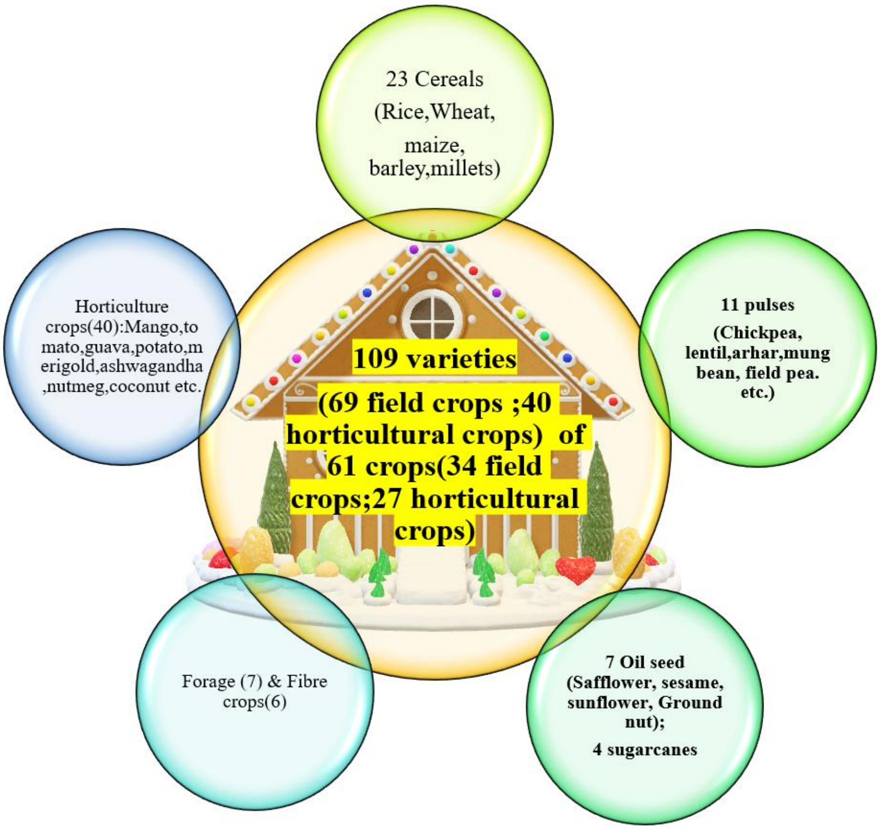


Fig.1. Graphical representation of 109 released varieties

These varieties are not just developed for yield and profitability, but also for:

- Drought, flood, salinity, and heat tolerance and resistance to pests and diseases
- Short maturity duration, allowing multiple cropping
- Enrichment with protein and micronutrients specially Fe and Zn to address malnutrition.

Innovation in Action: Crop-wise Highlights

1. **Rice**:
    - *DRR Dhan 58*: Submergence-tolerant; ideal for flood-prone eastern states.
    - *Pusa Basmati 1885*: Zn-enriched, early maturing, export-quality grain.
2. **Wheat**:
    - *HD 3386*: Tolerates late sowing and high temperatures.
    - *HI 1634*: A protein-rich wheat ideal for central India.
3. **Millets**:
    - *HHB 299 (Bajra)*: Rich in Fe and Zn; suitable for drylands.
    - *ICMV 221 (Ragi)*: Enriched with Ca and drought-tolerant.

4. **Pulses**:
    - *Pusa Chickpea 20211*: Wilt- and dry root rot-resistant.
    - *Pusa Arhar 16*: Short-statured variety ease in mechanical harvesting.
    - PSL-17: Suitable for salinity conditions, iron 67.0 ppm, zinc 28.8%, moderately resistant to wilt and rust lentil variety.
5. **Oilseeds & Cotton**:
    - *Pusa Mustard 30*: Salt-tolerant, early maturing.
    - New *Bt Cotton hybrids*: Resistant to pink bollworm.
6. **Horticulture**:
    - Climate-resilient mango, brinjal, tomato, banana, and turmeric.
    - Enhanced shelf life and nutritional properties — especially in mangoes.

Nutrition Security Through Biofortification

Out of the 109 newly released crop varieties, more than 20 are biofortified to enhance nutritional content, specifically addressing malnutrition issues. These biofortified crops are rich in Fe, Zn, protein, and provitamin A, helping tackle critical health concerns:

- Enriched Fe and Zn levels aim to reduce anaemia, particularly among women and children.
- Protein and provitamin A fortification supports child health and immunity.

These varieties align with India's Poshan Abhiyan and contribute to the achievement of Sustainable Development Goals (SDGs 2 & 3). Innovations like these are driven by ICAR's National Initiative on Climate Resilient Agriculture (NICRA) and All India Coordinated Research Projects (AICRPs) (NICRA 2024).

By enhancing the micronutrient content of staple foods, these biofortified crops play a crucial role in improving public health outcomes in the long term.

From Lab to Land: Ensuring Last-Mile Access to Climate-Resilient Seeds

The success of climate-resilient and biofortified crop varieties depends on their timely availability and adoption at the grassroots level. To achieve this, ICAR, in collaboration with Krishi Vigyan Kendras (KVKs), State Agricultural Universities (SAUs), and seed hubs, is actively working to:

- Conduct frontline demonstrations and farmer participatory varietal selection to build awareness and trust.
- Scale up quality seed production and ensure widespread distribution.
- Integrate with platforms like e-NAM and strengthen value chains for better market access.
- Promote extension services such as mobile apps, message alerts, farmer field schools, and direct scientist-farmer interactions for knowledge exchange.

The Ministry of Agriculture and Farmers' Welfare has announced that all 109 varieties of rice will be made accessible to farmers within three years, and efforts are being made to expand their adaptability to eco-friendly systems by making it compatible with natural farming.

Genome edited rice varieties in India

With the recent advancement of technology ICAR has developed India's first genome-edited rice varieties – DRR Rice 100 (Kamla) and Pusa DST Rice 1. These varieties have the potential to bring about revolutionary changes in terms of higher production, climate adaptability, and water conservation. In 2018, ICAR initiated genome-editing research to improve two major rice varieties – Samba Mahsuri and MTU 1010 – under the National Agricultural Science Fund in table no.1.

Table no.-1 Basic details of genome edited rice varieties in India in 2025

Sl. No.	Genome edited rice varieties of 2025	Centre of development	Parent	Special features
1.	DRR Rice 100 (Kamala)	ICAR-IIRR, Hyderabad	Samba Mahsuri (BPT 5204)	• Increased number of grains per panicle. • 20 days Early maturity (~130 days). • Rice quality similar to Samba Mahsuri.
2.	Pusa DST Rice 1	ICAR-IARI, New Delhi	MTU 1010	• Increase yields by 9.66% - 30.4% in saline and alkaline soils. • Up to 20% increase in production.

These rice varieties have been developed for states like West Bengal, Odisha, Jharkhand, Bihar, Uttar Pradesh, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Puducherry, Kerala, Chhattisgarh, Maharashtra, Madhya Pradesh. Behind the success, in the 2023-24 budget, the Government of India allocated ₹500 crores for genome editing in agricultural crops. ICAR has already initiated genome-editing research for several crops, including oilseeds and pulses (PIB,2025).

Conclusions and Way Forward

India has released 109 climate-resilient, high-yielding, biofortified crop varieties and genome edited varieties, marking a significant milestone in the country's agricultural transformation. These seeds are designed to tackle climate stresses and improve nutritional security, supporting national missions like Doubling Farmers' Income and Atmanirbhar Bharat. They align with global commitments under the G20 agriculture agenda and Sustainable Development Goals. However, successful adoption requires addressing challenges like timely seed availability, farmer awareness, and extension support, especially in remote and tribal regions. Strengthening seed value chains, promoting participatory varietal selection, and compatibility with natural farming systems are crucial. Investments in weather-based insurance, climate forecasting tools, and risk mitigation mechanisms will also safeguard farmer livelihoods. India's Lab-to-Land model is paving the way for a greener, healthier, and more sustainable agricultural future.

References

Indian Council of Agricultural Research (ICAR). (2024). *109 Climate-Resilient Varieties Released by Hon'ble Prime Minister on 11th August 2024*. ICAR, New Delhi.

National Innovations on Climate Resilient Agriculture (NICRA). (2024). *Climate Resilient Technologies and Crop Improvement Initiatives*. ICAR-NICRA, New Delhi.

Press Information Bureau (PIB), Government of India. (2024, August 11). *PM releases 109 varieties of climate-resilient, high-yielding, and biofortified crops developed by ICAR*.

Press Information Bureau (PIB), Government of India. (2025, May,5). *Union Agriculture Minister Shri Shivraj Singh Chouhan Announces Two Genome-Edited Rice Varieties Developed in India.*

.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/38/0625

SMART AQUAPONICS: INTEGRATING AI AND IOT FOR SMART FARMING IN INDIA

Bharath G[1] and Murtaza Hasan[2]*

[1]Ph.D. Scholar, Division of Agricultural Engineering,
ICAR–Indian Agricultural Research Institute, New Delhi, India
[2]Principal Scientist, Centre for Protected Cultivation Technology,
ICAR–Indian Agricultural Research Institute, New Delhi, India
Corresponding Email: bhg3011@gmail.com

Introduction

Aquaponics, the synergistic combination of hydroponics and aquaculture, is a sustainable farming practice that brings solutions to the growing issues of food security, resource depletion, and environmental degradation. In the Indian context, where agriculture contributes significantly to the economy and livelihood, the implementation of new techniques in farming is the need of the hour. The merger of Artificial Intelligence (AI) and the Internet of Things (IoT) with aquaponics, called "Smart Aquaponics," is poised to transform contemporary agriculture through increased efficiency, productivity, and sustainability. As India walks towards agricultural modernization and indigenization, the use of AI and IoT in aquaponics systems is a vast promise to make agriculture smarter, sensitive, and frugal.

Evolution of Aquaponics and the Need for Smart Farming

India's traditional farming has traditionally relied on soil-based cultivation, which is susceptible to unpredictable climatic fluctuations, soil erosion, and high water consumption. With the critical issues of diminishing arable land, rising food demand, and climate uncertainty, aquaponics has emerged as a potential substitute. This closed-loop process, in which fish waste feeds plants with nutrients and plants clean and filter water for fish, is a sustainable one that drastically minimizes water usage and removes the use of chemical fertilizers. Nevertheless, conventional aquaponics systems also need to be monitored constantly and require manual adjustments, which are often inefficient and labor-intensive. This is where IoT and AI come in to effect a revolutionary change, turning aquaponics into a data-driven, automated, and smart farming technique.

AI and IoT Integration in Aquaponics

Integration of AI and IoT technologies into aquaponics revolutionizes traditional farming into an intelligent, real-time monitored and automated farming system. IoT-based sensors are critical in gathering real-time information regarding important parameters like water quality, temperature, pH, nutrient levels, and fish health. These sensors ensure real-time monitoring, allowing for the early identification of imbalances or anomalies in the system. This information is sent to cloud platforms where AI-driven algorithms analyze and process it to maximize system performance, forecast impending problems, and automate decision-making.

Predictive analytics driven by artificial intelligence greatly improve the productivity of aquaponics systems by predicting water chemistry changes, identifying initial symptoms of disease among fish, and suggesting modifications in feeding times. Machine learning algorithms, programmed on past records, are able to predict fluctuations in pH levels, dissolved oxygen levels, and ammonia concentration, making interventions proactive before dangerous limits are crossed. Additionally, AI-based automation does away with the necessity for continuous human supervision by controlling water flow, aeration, and lighting systems depending on real-time needs. Not only does it decrease manual efforts, but operational expenses are also minimized, leading to increased overall yield.

Remote management features enhance the advantages of combining AI and IoT in aquaponics further. Aquamonitor farmers are able to keep track and adjust their aquaponics systems remotely through smartphone applications or internet web interfaces so they can instantly be notified, visualize system trends, and control parameters remotely. Through this ease of access, farm operations remain intact and uninterrupted even when the farmer is away from the location. In addition, decision support systems through AI processes offer actionable insights by evaluating enormous datasets, which helps farmers, make decisions on fish stocking density, choice of crops, harvest schedules, and adding nutrients.

Advantages of Smart Aquaponics in India

The use of AI and IoT in aquaponics is commensurate with India's food production transformation goals by encouraging the use of available resources, being sustainable, and increased productivity. Water conservation ranks among the leading benefits. Soils-based traditional farming requires an enormous amount of water, which is lost either through evaporation or improper irrigation. Aquaponics, in comparison, gets to utilize even 90% less water as it recirculates in the system. IoT monitoring also ensures proper water usage by identifying leaks, evaporation levels, and nutrient deficiencies, reducing wastage accordingly.

Energy efficiency is another vital advantage. Smart automation maximizes energy efficiency through the control of aeration, lighting, and pumping systems depending on real-time demand. AI-based algorithms are able to change energy consumption in order to synchronize with off-peak hours or renewable energy availability, lowering the cost of operations and encouraging green energy consumption. In addition, AI-based aquaponics breaks the reliance on chemical fertilizers and pesticides since the closed-loop system naturally regulates nutrient levels and prevents pest infestations. This not only results in healthier crops but also ensures environmental sustainability as it minimizes agricultural runoff and chemical contamination.

Increased yield and productivity are another core benefits. By constantly monitoring environmental conditions and plant growth patterns, AI optimizes farm conditions to achieve maximum output. Conventional methods of farming are usually plagued by irregular weather patterns, infestations, and soil loss, all of which have a major effect on output. With AI-operated aquaponics, however, there is a secured environment in which factors like temperature, humidity, and nutrient content are kept at optimal levels. This is conducive to all-year-round growth and increased yields per crop, posing aquaponics as a feasible option for remedy of India's food security issues.

Challenges and Considerations

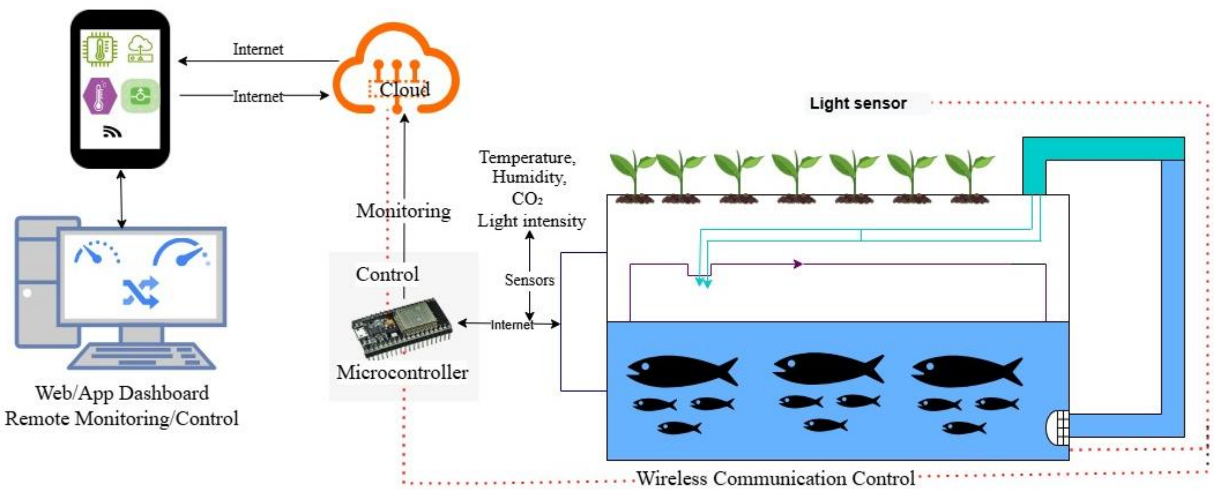
Despite the huge promise of Aquaponics 2.0, there are a number of challenges that need to be overcome for widespread adoption in India. One of the foremost challenges lies in high initial investment for establishing smart aquaponics systems. IoT sensors, AI codes, cloud storage, and automated control systems require heavy capital outlay, which could be costly for small farmers. While long-term running cost savings and improved efficiency can negate these benefits, it is necessary to have financial backing in terms of government grants, subsidies, and low-interest loans to make it affordable.

Technical know-how is another essential aspect. In contrast to conventional agriculture, AI and IoT-based aquaponics require some technical know-how for installation, management, and maintenance. Farmers need to be trained with digital literacy and training modules to properly use these intelligent systems. To fill this gap, there is a need for cooperation among agricultural institutions, technology companies, and government agencies to offer hands-on training, workshops, and user-friendly interfaces designed for farmers with minimal technical knowledge. Data privacy and security issues also pose possible hindrances in AI and IoT application in aquaponics. As farm operations increasingly rely on digitization, harvesting and transmitting sensitive data must be protected from cyber threats. Application of strong encryption policies, secure cloud storage systems, and tight access controls can avoid risks due to data breaches. In addition, setting up regulatory systems to sustain ethical utilization of AI and ethical data handling is vital to ensure trust and transparency.

Infrastructure constraints are another challenge, especially in rural communities where internet and electricity connectivity is still not stable. IoT aquaponics systems depend on continuous internet connectivity to monitor remotely in real time and analyze using the cloud. Where network coverage is poor, other solutions such as edge computing, offline data storage, and satellite connectivity can be used to mitigate these constraints. Also, incorporation of renewable sources of power such as solar can provide consistent functionality in cases where electricity supply is unreliable.

Future Prospects and Recommendations

Smart Aquaponics has huge potential India, as long as strategic efforts are made to make it adoptable and scalable. Smart farming technologies can be promoted by government policies in the form of subsidy incentives, tax relief, and research grants to advance the way to AI and IoT-based aquaponics. Public-private partnerships can spur innovation, bringing technology developers, agricultural scientists, and farmers together to create cost-effective and scalable solutions as per Indian conditions. Education and training programs to build capacity are essential to enable farmers with skills required to operate and manage smart aquaponics systems. Extension services, vocational training centers, and agricultural universities can be central in sharing information and best practices. Making interfaces easy to use with regional language support can enhance further accessibility and adoption by farmers of different linguistic backgrounds.



In addition, promoting research and development of AI-based precision agriculture can result in revolutionary developments in aquaponics. Utilizing big data analytics, genomics, and remote sensing technologies, AI can maximize plant and fish health, optimize breeding programs, and enhance utilization of resources. Supporting startups and agritech companies to create innovative AI and IoT technologies customized for small farmers can fill the technological divide and make smart farming accessible to all.

As India adopts digital revolution in agriculture, the confluence of AI and IoT in aquaponics marks a shift towards sustainable, smart, and resource-conserving farming. With its ability to tackle current challenges and create an innovation and collaboration ecosystem, Aquaponics 2.0 can transform Indian agriculture, guaranteeing food security, environmental stewardship, and economic prosperity for generations to come.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

Article ID : 05/VI/39/0625

A SUCCESS STORY OF AN ORGANIC FARMER OF BAREILLY DISTRICT OF UTTAR PRADESH

Monika Jha[1], Snehasish Routray[2*], Kailashpati Tripathi[3], Ashutosh Fular[4], Mranalini Prerna[5], Anjali[6], K.A. Saravanan[7], Jagdish Goyanka[8], Anuj Chauhan[9], Brijesh Kumar[10], Rupasi Tiwari[11] and S. K. Soam[12]

[1]Scientist, Division of Plant Exploration and Germplasm Collection, ICAR- National Bureau of Plant Genetics Resources, New Delhi
[2]Scientist, Division of Crop Protection, ICAR-Central Institute for Subtropical Horticulture, Lucknow
[3]Scientist, Basic & Strategic Research Unit, ICAR- NRC on Seed Spices, Tabiji, Ajmer, Rajasthan
[4]Scientist, Temperate Animal Husbandry division, ICAR-Indian Veterinary Research Institute, Mukteswar, Uttarakhand
[5]Scientist, Camel Health and Research Laboratory, ICAR-NRC on Camel, Bikaner, Rajasthan
[6]Scientist, Division of Cattle Physiology and Reproduction, ICAR -CIRC, Meerut, Uttar Pradesh
[7]Scientist, Division of Animal Genetics and Breeding, ICAR-Central Sheep and Wool Research Institute, Avikanagar, Rajasthan
[8]Scientist, ICAR- Directorate of Mushroom Research, Solan, Himachal Pradesh
[9]Swine production farm, LPM Section, ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh.
[10]Division of Animal Reproduction, ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh
[11]Joint Director (Extension Education), ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh
[12]Principal Scientist, Department of Information and Communication Management, ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana.

*Corresponding Email: snehasishroutray@gmail.com

Abstract

This paper highlights the inspiring journey of Mr. Om Prakash, a 62-year-old farmer from Hamirpur village, Bareilly, Uttar Pradesh, who successfully transitioned from chemical-based to organic farming. Initially facing challenges associated with conventional practices, Mr. Prakash recognized their detrimental effects on soil health and crop productivity. Following training sessions and support from organizations like ICAR-IVRI and Krishi Vigyan Kendra, he adopted organic and natural farming, leveraging local bioresources and eco-friendly methods. His farm, now a model of sustainability, incorporates innovative practices such as crop rotation, intercropping, and utilization of biopesticides. Despite lower initial yields, he achieved greater income due to the higher market value of organic produce. His methods have influenced local farmers and promoted community-wide shifts towards sustainable agriculture. This success story serves as an example of how traditional farming combined with modern organic practices can foster economic, environmental, and social benefits.

Key words : Organic farming, agricultural sustainability, bioresource cycling, paradigm shift

Introduction

In climate changing scenarios and modernization of farming, the harsh impacts of harmful synthetic chemical-based farming have been well realized by all stakeholders in modern society. While many applaud the possible positive influence of the practice of natural and organic farming, many criticize the same in the name of lower productivity and other marketability issues. Amid all, a 62 years old farmer named Mr. Om Prakash has made an exemplary achievement in organic farming practice at the village Hamirpur of Bareilly, Uttar Pradesh (UP). He owns 7.58 ha of land and he pulls out the profitable output from Mentha, wheat, rice, poplar, chilli and marigold-based organic farming with the use of on-farm residual resources, cow-based products and other local plant-based botanicals.

Motivation and Training

In his initial days of farming, he was practicing chemical-based farming in his field. Later on, he realized that these expensive chemical products were harming the land and depleting the soil of nutrients and microbiological diversity, like useful bacteria and fungi. Over time, this made the land less productive, meaning declining yields for all his crops.

In 2018, he underwent training on organic farming at Jaivik Krishi Sansthan, Majhkhali, Almora, Uttarakhand under the encouragement from the UP-state agriculture department (Fig. 1). This training imparted a large influence on his thought and practice as a farmer and slowly he started shifting his chemical-based farming to purely organic farming in varieties of crops on his field. Again, he attained two training sessions at Rajya Krishi Prabandhan Sansthan, Rehmankhera, Kakori, UP on *Paranli Prabandhan* (crop remnants) and Natural farming (*Prakrutik kheti*) during 2021-22. In 2018, Hamirpur was adopted by Krishi Vigyan Kendra (KVK), ICAR-Indian Veterinary Research Institute (IVRI), Bareilly, Uttar Pradesh. Various trainings by KVK on these aspects also influenced Om Prakash to practice organic and natural farming. With his progressive, enthusiastic, and curious approach to farming, he began adopting organic farming on a portion of his land. The initial good results and subsequent good demand for organic products in those areas led him to fully embrace organic farming for all his crops, including mentha, paddy, wheat, poplar, chilli and marigold by 2020.

Fig. 1: Participation in training programmes organized by different organizations

Achievements

After transitioning to organic farming on his land, he experienced a remarkable increase in demand for organic products from various stakeholders. Despite achieving lower yields compared to his previous chemical-based farming practices, his recognition of the superior quality of the products and the high demand for them motivated him to continue with organic farming. Initially, he harvested approximately six quintals of wheat from 0.5 ha of land using conventional methods, selling it at ₹2100.00 per quintal. However, with organic farming, he only yielded around 3.5 q of wheat but sold it at ₹5000.00 per quintal. He noted a significant increase in demand for organically grown produce from various consumer groups. Additionally, he observed that chemical-free farming had no detrimental impact on the ecosystem.

Subsequently, he adopted natural farming methods across his entire field, employing homemade biostimulants such as ghanjeevamrut and jeevamrut, along with biopesticides like neemastra and other neem and karanj-based formulations. Vermicompost served as a primary source of nutrients for his crops, while manual weeding helped manage weed growth. Embracing natural farming not only reduced his expenses but also increased his income and enhanced soil health by enriching soil fauna, such as earthworms and implementing intercropping techniques. This approach involved cultivating compatible crops together to leverage their natural synergies, resulting in overall higher yields. For example, certain crops provided essential nutrients for others or acted as natural pest repellents, benefiting neighboring crops.

Omprakash Ji remarked, "With chemical farming, we were limited to cultivating only a few crops. However, with natural farming, we can cultivate three to four intercrops, such as pulses, chili and turmeric, providing additional income and nutrition." Recently, he began growing datura as border cropping due to its insecticidal properties. Additionally, he incorporated several Indigenous Technological Knowledge (ITKs) to control pest populations in the field.

Bioresource recycling

He possessed expertise in efficiently managing agricultural waste and residues. For example, waste from cereal crops, such as bran and straw, was repurposed as animal feed. Additionally, animal waste was utilized to create organic manure and bio-stimulants, which were then used as organic sources of nutrients for crop production. Poplar leaves (*Populus ciliata*) were also employed in the production of manure. Furthermore, after oil was extracted from the leaves, the remaining residue was used as fuel in the extraction unit of mentha oil. He gained recognition for his success with natural farming methods from various research organizations as well as district-level programs. Many common agricultural practices in used globally, such as monocropping or overreliance on chemicals, are not sustainable. They degraded soils, caused tremendous stress on water resources, and affected the profits, health, and livelihoods of farmers. Natural farming methods showed that there was an alternative. The brief of the bioresource recycling has been shown in Fig. 2.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed monthly newsletter

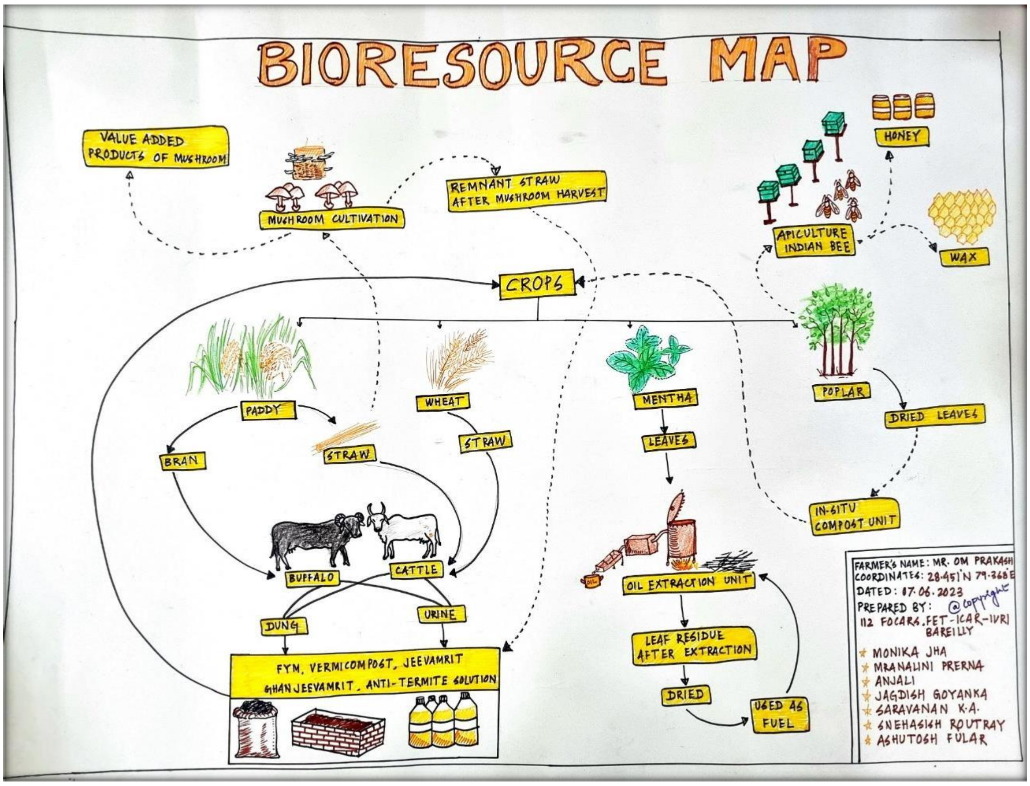


Fig. 2 Bioresource flow map of the farm unit of Mr. Om Prakash.
: Actual bioresource flow (Possible ways for additional income)

Award and recognition

Due to his ongoing endeavors to promote organic and natural farming, he has received recognition from IVRI and the State Agriculture department on numerous occasions. Additionally, the district magistrate has commended him for his successful endeavors in advancing green agriculture as shown in Fig. 3.

Fig. 3 Recognition and certificate of appreciation from various organization

Impact on local villagers

The success of organic farming on Omprakash's farm inspired others in his village. Presently, the state agriculture department is organizing a cluster of organic farming on 20 ha of land under Mr. Om Prakash's guidance. He has personally taken it upon himself to educate the villagers about the positive effects of organic farming. Additionally, he has mentored other unemployed youths in the village, encouraging their participation in various training programs at the nearby KVK. "I invited them to delve into my soils to observe the abundance of earthworms compared to fields where chemical fertilizers are utilized," Omprakash explains. Earthworms flourish in healthy soils, enhancing soil health by increasing nutrient availability, improving drainage, and stabilizing soil structure, all of which contribute to enhanced farm productivity. As expected, he notes, "We found a significantly higher number of earthworms in fields practicing natural farming."

Paradigm shift (in farmer's perspective)

Resources/ parameters	Before opting organic farming	After opting organic farming
Farm equipment	Tractor, power tiller, knapsack sprayer	Tractors, cultivator, power sprayer, tiller, cultivator, harrow, rotavator, knapsack sprayer
Quality	Quality of the produces was not satisfactory from consumer point of view.	The produce was of better quality and that fetched better price. Awareness about organically grown farm produces such as, wheat, rice, mentha oil, mustard and others were more preferred by the local consumers.
Total Yield	Higher yield Paddy: 12 q/ acre Wheat: 15 q/acre	Comparatively lower yield Paddy: 9-10 q/ acre Wheat: 10-12 q/ acre
Annual income	Was lower (7-8 LPA* approx.)	Overall annual income was higher than the previous cropping system because of the better preference of the consumers (10-12 LPA approx.)
Intercropping	Lesser extent of intercropping	More preference to intercropping including agri-silvicultural system
Recycling of farm residues	Much lower extent	Primary focus was on the recycling of the on-farm resources depending on FYMs, crop residues etc.
Inclusion of Animal husbandry	Nil	1 cattle
Water	More water was used	Lesser quantity has been adopted
Use of biopesticides	Lesser extent	More reliance on cow dung, cow urine and botanical based plant protection.

*LPA- lakhs per annum

Interventions

In the future, there will be significant potential to enhance the secondary source of income on Mr.

Om Prakash's farm. He will be able to utilize the leftover straw from his fields for mushroom cultivation. Additionally, there will be opportunities to engage in commercial beekeeping by utilizing bee foraging plants like poplar, eucalyptus, and others. Farmers like Mr. Omprakash will play a crucial role in promoting organic and natural farming, which will be highly sought after in the current era. By embracing these practices, smallholder farmers will reduce input costs, increase yields, and create more sustainable farming conditions, all while providing consumers with chemical-free, high-quality food. The promotion of these simple, natural methods will pave the way for a more sustainable agricultural sector, leading to positive changes for our planet.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/40/0625

MORPHOTYPES OF SWEET ORANGE FOUND IN MANIPUR, NE INDIA

S. Romen Singh* and Rahul Senjam

Department of Horticulture
College of Agriculture, CAU, Imphal, Manipur
*Corresponding Email: romensenjam@yahoo.com

Introduction

Sweet orange (*Citrussinensis*is) belongs to subfamily Aurantioideae and family Rutaceae. The genus citrus consists of true citrus species *viz*. *Citrus reticulate, Citrus medica* and *Citrus maxima*. It is originated from Southeast Asia. This species is grown in many tropical and subtropical regions. It occupies nearly 50% of total area under citrus cultivation. India ranks third in the production of orange after banana and mango fruit.In India, North Eastern India is claimed as centre of origin for citrus species (Sunaiana *et al.,*, 2020). In Manipur, the North East region, a local sweet orange variety known as *Heithum* held a significant position among the other sweet orange kinds found in various parts of India, including Valencia, LateValencia, Mosambi, Sathgudi, Malta and Jaffa. Tight-skinned oranges from the *Citrus sinensis* species are frequently referred to as Heithum in Manipur's sweet orange type. Assam, Tripura, and Nagaland are the principal contributors to the nation's sweet orange output, accounting for the majority of India's total production (Nilakshi *et al.,* 2022). Around the world, people eat *C. sinensis* because it is a great source of vitamin C, a potent natural antioxidant that strengthens the body's defences. Constipation, cramps, colic, diarrhoea, bronchitis, tuberculosis, cough, cold, obesity, menstruation disorders, angina, hypertension, anxiety, depression, and stress, asthma, vomiting, fever, hiccoughs, and indigestion are just a few of the conditions it has been used to treat traditionally. Oranges have long been used in Chinese traditional medicine as a cooling remedy for respiratory conditions like colds and coughs. In China, it is regarded as a traditional lucky charm. (Priti Dongre *et al.,* 2023).

Despite the fact that citrus is widely grown in the North East, the primary producing zones for this fruit crop are Assam (Tinsukia, NC Hills, KarbiAnglong), Tripura (Jampui Hill), Meghalaya (East & West Khasi, Ri-Bhoi, Garo Hills, Jaintia Hills), Manipur (Tamenglong, Ukhrul, Thoubal,Kakching and some area of Imphal East & Imphal west), and Arunachal Pradesh (East Siang). *Heithum*, a native sweet orange variety in Manipur, has been flourishing for ages, yet its seedlings' origin is unclear. Because of its sweetness and juicy character, consumers enjoy this indigenous sweet orange type, which grows in the Manipur foothills, for desert purposes. However, farmers in Manipur are cultivating seedlings with unclear yield potential and fruit quality because there hasn't been any study done on crop development or the selection of the elite genotype of this native sweet orange variety.

In Manipur Sweet Orange is availability of different size and fruit quality having sour and sweet in taste. TSS ranging from 6.4-11.9 ^{o}Brix and locally sweet orange is known as '*Heithum*' are mostly grown in homestead garden in valley area and mostly are cultivated in foothills area to cultivate for commercial in Ukhrul, Kamjong and Tamenglong districts. Considering the significance of this fruit, its nutritional and therapeutic qualities are currently driving up demand for its planting material. The sweet orange (*C. sinensis*) is a cross between a mandarin and a pummelo. Sweet orange locally known as '*Heithum*' genetic diversity is quickly declining due to a variety of variables, including the introduction of genotypes appropriate for intensive horticulture and selection that displaces the natural gene pool, resulting in a limited gene pool which need conservation of the elite germplasm found in Manipur.

Distribution in North East India

Citrus crops are grown on 19,117 hectares and produce 119,749 tonnes annually, making them the third largest crop in the North Eastern Region in terms of both area and production. The top states in terms of area and output are Meghalaya, Assam, Manipur, Sikkim, Tripura, Mizoram, Nagaland, and Arunachal Pradesh.

Taxonomy description of sweet orange morphotypes in Manipur

Leaves: The length of leaves lamina is 6.2 cm and width of leaves lamina is 3.1 cm. The leaf aroma is average. Vegetative life cycle of sweet orange is deciduous. Leaf division is simple in shape. Most of the citrus leaf lamina shape available in Manipur is obovate type and leaf lamina margin is entire. Brevipetiolate (Petiole shorter than leaf lamina) in leaf lamina attachment.

Flower: In Manipur most of the sweet orange are started blooming in the month of mid-March to first week of April. The colour of the flower is light pink to whitish in colour. It has five petal five sepal and fourteen stamens with a superior ovary.

Seeds: Sweet orange (*citrus sinensis*) seed have faith yellowish to pale white. They are angular, oval and flattened. The length of the seed is 1.1mm to 1.7mm and seed width is 0.5mm to 1mm. The embryos are either or zygotic, and the seed are polyembryony. Zygotic embryos are produced from ovarian pollination, while nuclear embryos are entirely derived from the mother plant and exhibit largely similar traits that are similar to those of the parent plant.

Fruit: The shape of the fruit is Ellipsoid, Spheroid and Obloid type. The weight of the fruit is 142 to 232g.Fruit width is 4.5 to 8.2 cm and fruit length is 5.5 to 7.5 cm. The pericarp and endocarp are the two separate anatomical sections that make up the fruit. The endocarp is also referred to as pulp or juice sacs, and the pericarp is also known as the peel, skin, or rind. Fruit rind is 0.3 to 0.7 cm. The total segment of the fruit is 10 to 12.The skin has an epidermis of epicuticular wax and many tiny, fragrant oil glands. The distinct scent comes from this oil gland.The tissue mass crushed into the intercellular space is made up of tubular-like cells that make up the albedo, or mesocarp, which lies beneath the flavedo. Flavonoids, which are abundant in the albedo, can be added to the juice adds a bitter flavour. Usually, the pulp is juicy and delicious. There are ten (10) to fourteen (14) segments in the meat or pulp. The ripe fruit belongs to a class of berry called a hesperidium, which is fleshy and has several seeds. Sugars, organic acids, and a lot of water are accumulated in gaudy juice sacs. It is making it more difficult to extract proteins and nucleic acids and proteins (Etebu, *et al.,*, 2014), (Milind and Dev, 2012).

Conclusion

Sweet orange has developed significant genetic variation over generation in Manipur due to its seedling population; it is growing in different parts of foot hills and valley in Manipur.Additionally, its characterisation can help identify superior genotypes of *Heithum* that are found growing in Manipur, Northeast India. Therefore, screening and selection of superior genotypes are necessary for germplasm conservation of this important citrus species.

Fig1: Morphotypes of sweet oranges found in Manipur, NE India

Acknowledgement

We would like to acknowledge the Innovative IPR project funded by Central Agricultural University, Imphal, Manipur for the cooperation during the research.

References

Etebu, E. and Nwauzoma, A. B.(2014). A review on sweet orange (*Citrus sinensis* Osbeck): health, diseases, and management. *American Journal of Research Communication*, 2(*2*): 33-70

Milind, P. and Dev, C. (2012). Orange range of benefits. *Agricultural and Food Sciences.* 3(*7*), 103. 59-63

Nilakshi Bordoloi, L. Wangchu and P.K. Nimbolkar (2022). Citrus Budding: Research Perspectives and Recent Trends. *Biological Forum – An International Journal.* 14(*3*): 841-849.

Priti Dongre, Chandrashekhar Doifode, Shaily Choudhary, Neeraj Sharma (2023). Botanical description, chemical composition, traditional uses and pharmacology of *Citrus sinensis*. *Pharmacological Research Modern Chinese Medicine*. Volume 8.

Sunaiana, M Gupta, Rattanpal, HS, Sidhu, GS and Singh, G. (2020). Morphological Characterization of Sweet Orange (Citrus sinensis Osbeck) Germplasm under Subtropical Conditions. *Indian J. Plant Genet. Resource*. 33(*2*): 224–229.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 05/VI/41/0625

UNRAVELING FASHION'S CARBON FOOTPRINT: STEPS TOWARD A GREENER FUTURE

Minakshi Sharma[1*] and Parul Gill[2]

[1]Ph.D scholar, Deptt. of Apparel and Textile Science,
I.C. College of Community Science
CCS Haryana Agricultural University, Hisar- 125004, Haryana
[2] Assistant Scientist, Deptt. of Apparel and Textile Science,
I.C. College of Community Science, CCS Haryana Agricultural University,
Hisar- 125004, Haryana
[*]Corresponding Email: sharmaminakshi2425@gmail.com

Abstract

The fashion industry is a major contributor to global greenhouse gas emissions, accounting for approximately 8-10 percent of the total. Its environmental impact spans multiple stages, including raw material production, fabric dyeing, garment manufacturing, and waste disposal. Addressing these challenges requires a comprehensive shift toward sustainability by adopting eco-friendly materials, energy-efficient technologies, and circular fashion models that promote reuse and recycling. Achieving meaningful emission reductions demands collaboration among all stakeholders: brands, consumers, and governments. Brands must integrate sustainable practices throughout their supply chains, consumers must make mindful purchasing and care choices, and governments should implement supportive policies and regulations. Together, these efforts can drive the transformation of the fashion industry into a more sustainable and responsible sector, mitigating its environmental footprint while continuing to meet global demand.

Keywords: sustainability, fashion industry, carbon footprint and textile waste

Introduction

The fashion industry is a global powerhouse setting trends, fueling economies, and serving as a form of self-expression. However, beneath the surface of its glitz and glamour lies a growing environmental crisis. As concerns over climate change escalate, the industry's significant carbon footprint is increasingly coming under scrutiny. According to the United Nations Environment Programme (UNEP), the fashion industry is responsible for approximately 8 to 10 percent of global greenhouse gas emissions. Beyond its contribution to climate change, the industry also exerts significant pressure on water resources, depleting water sources and polluting rivers and streams through textile production and dyeing processes. Even more concerning, around 85 percent of all textiles end up in landfills each year, underscoring the vast amount of waste the industry generates. Moreover, washing synthetic garments releases an estimated 500,000 tons of microfibres into the ocean each year, equivalent to around 50 billion plastic bottles. The environmental impact of this pollution is staggering, surpassing even the combined greenhouse gas emissions of all international flights and maritime shipping. **Understanding the Carbon Footprint of Fashion**: A carbon footprint refers to the total emissions of greenhouse gases, mainly carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) resulting from human activities. In the fashion industry, this footprint covers the entire lifecycle of a garment, from raw material extraction and production to use and eventual disposal. To break it down, the fashion industry's carbon footprint includes emissions generated from the cultivation and extraction of raw materials, such as cotton, wool and synthetic fibres, textile processing and fabric dyeing, which often involve high energy consumption and the use of harmful chemicals, garment manufacturing, including cutting, sewing, and finishing processes, packaging and global transportation, contributing to emissions through logistics and distribution, retail operations, encompassing energy use in stores, warehouses and supply chain infrastructure, consumer usage, including frequent washing, drying and ironing, which add to the garment's carbon footprint, end-of-life disposal, whether through landfilling, incineration, or recycling of used clothing.

Key Contributors to Fashion's Carbon Footprint

1. Raw Material Production: Raw material sourcing significantly determines a garment's carbon footprint. Different materials have different environmental costs. Cotton, though often regarded as an eco-friendly natural fibre, has a substantial environmental impact. Conventional cotton farming consumes enormous amounts of water, approximately 20,000 litres to produce just 1 kilogram of cotton, and depends heavily on pesticides and synthetic fertilisers. These chemicals release nitrous oxide, a greenhouse gas that is 300 times more potent than carbon dioxide. Polyester, the most widely used textile globally, is derived from petroleum-based resources. Its production emits approximately 9.52 kilograms of CO_2 per kilogram of fabric, nearly three times more than cotton. Furthermore, polyester is non-biodegradable, significantly contributing to microplastic pollution in marine environments. Wool and leather production contribute to methane emissions from livestock and often drive deforestation to create grazing land. Additionally, both require intensive water and energy use. The tanning and dyeing processes for leather also generate hazardous waste.

2. Textile Processing and Dyeing: The transformation of raw fibres into finished fabrics involves multiple stages such as spinning, weaving or knitting, dyeing, and finishing, all of which require substantial amounts of electricity, water, and chemicals._Dyeing poses significant environmental challenges, contributing to approximately 20 percent of global water pollution. Conventional dyeing processes use heated water and toxic chemicals, which are frequently released untreated into rivers, damaging aquatic ecosystems and impacting local communities. Finishing treatments, including wrinkle resistance, water repellency, and anti-stain coatings, often depend on perfluorinated compounds and other chemicals that are both harmful and persistent in the environment. Textile mills, particularly in regions with lax environmental regulations, often operate using coal-powered electricity, adding further emissions to the supply chain.

3. Garment Manufacturing: Once fabrics are produced, they are cut, sewn, and assembled into garments mainly in developing countries like Bangladesh, Vietnam, and India. In these regions, energy is often sourced from fossil fuels. Outdated, inefficient machinery and inadequate factory infrastructure further increase energy consumption. Labour practices also impact emissions. Inefficient planning and overproduction generate excessive inventory and waste. With its rapid release of new collections, the fast fashion model results in billions of garments produced each year, many of which remain unsold or unworn. Packaging materials, such as plastic polybags and tags, contribute additional carbon emissions and waste during this stage.

4. Transportation and Global Supply Chains: Fashion is a global industry, with a single item often involving cotton grown in the US, spun in India, woven and dyed in China, stitched in Bangladesh, and finally sold in Europe or North America. Global transportation, including shipping, trucking, and air freight, is a major source of emissions. Although ships are relatively fuel-efficient, they rely on heavy fuel oil, which releases significant amounts of CO_2 and sulphur dioxide. In contrast, air freight, commonly used to meet fast fashion deadlines, has a much larger carbon footprint. The 'just-in-time' production model, where brands manufacture based on rapidly changing sales trends, leads to frequent, small shipments. This increases the total number of deliveries and, consequently, overall emissions.

5. Consumer Use: Once purchased, clothing continues to contribute to emissions during its use phase: Washing and drying contribute to roughly 25 percent of a garment's total carbon footprint over its lifetime. These processes consume large amounts of electricity and water, especially when powered by fossil fuels. Ironing, though often overlooked, also increases the overall footprint, particularly in regions with energy-intensive electricity grids. Washing synthetic garments like polyester and nylon releases microfibres, tiny plastic particles that pollute waterways. Adopting more sustainable clothing care habits, such as using cold water, line drying, and washing less frequently, can significantly reduce this impact.

Is a Sustainable Future Possible for the Fashion Industry?

Reducing the fashion industry's carbon footprint is a complex challenge, but it is achievable.

1. Sustainable Materials: Adopting eco-friendly alternatives to conventional textiles can reduce emissions significantly: Organic Cotton is cultivated without harmful chemicals, using crop rotation and composting to preserve soil health. It requires less water and generates fewer emissions compared to conventional cotton. Hemp and Linen fibres need minimal water and pesticides. Notably, hemp absorbs CO_2 as it grows, making it a carbon-negative crop. Innovative fibres are such alternatives like Tencel, Piñatex and Mylo offer a lower environmental impact. Recycled fabrics, which use recycled polyester, nylon and cotton, help reduce reliance on virgin materials and minimize textile waste.

2. Greener Manufacturing Practices: Sustainable production requires a shift in how clothes are made: Energy-efficient machinery lowers power usage throughout the manufacturing process. Renewable energy sources, such as solar and wind, can provide cleaner power for textile mills and factories. Closed-loop systems recycle water and chemicals used in dyeing, helping to prevent pollution and cut emissions.

3. Localised and On-Demand Production: Shortening the supply chain reduces transportation emissions and waste. Local manufacturing enables faster responses to fashion trends while minimizing the reliance on large-scale overseas shipping. On-demand production, where garments are made only after they are ordered, helps prevent overproduction and excess inventory.

4. Educating and Empowering Consumers: Consumers have the power to drive change. By making thoughtful choices, individuals can reduce fashion's environmental impact: Buy less, choose better. Prioritizing high-quality, timeless garments minimizes the need for frequent replacements. Practice conscious washing: Using cold water, line drying, and eco-friendly detergents helps lower environmental impact.

5. Government Policy and Industry Collaboration: Widespread change requires regulatory support and industry-wide cooperation. Extended Producer Responsibility (EPR) laws require brands to take accountability for their products throughout their entire lifecycle. Carbon taxes and incentives motivate companies to implement cleaner, more sustainable technologies. Supply chain transparency regulations facilitate better monitoring of environmental and social practices. Public-private partnerships provide funding to support sustainable innovation and infrastructure development.

Steps Towards Reducing Fashion's Carbon Footprint:

- Transitioning textile mills and garment factories to renewable energy sources such as solar, wind, or hydropower can significantly reduce emissions, particularly in areas still dependent on coal-fired power. Brands can facilitate this change by investing in factory upgrades or collaborating exclusively with suppliers committed to renewable energy targets.
- Cutting back on synthetic fabrics like polyester, which is petroleum-based, also helps lower emissions. Polyester production generates nearly three times more CO_2 than cotton and contributes substantially to microplastic pollution.
- Implementing sustainable practices throughout the supply chain, such as regenerative agriculture for natural fibres, closed-loop dyeing processes, and localized production, can result in more environmentally responsible outcomes.
- Designing garments for durability, reuse, and recyclability helps reduce the amount of clothing discarded in landfills.
- Limited transparency makes it challenging to monitor emissions across the fashion supply chain. Brands need to map their supply chains, pinpoint carbon-intensive stages, and collaborate with suppliers to set clear emissions-reduction goals.

Conclusion

The fashion industry stands at a pivotal moment. Its significant carbon footprint presents both a major environmental challenge and a unique opportunity. Through a combination of innovation, shifts in consumer behaviour, and strong policy support, the industry can cut emissions and spearhead a sustainability revolution. Going green goes beyond just fabrics and factories; it means reimagining the entire fashion system, from design to disposal. This transformation demands collaboration among brands, manufacturers, governments, and consumers alike. Every decision counts. Whether by choosing ethical brands or caring for clothes more thoughtfully, small actions collectively make a big impact. The future of fashion can be stylish, inclusive, and sustainable if we all commit to playing our part.

References

https://www.unep.org/news-and-stories/press-release/unep-and-un-climate-change-provide-fashion-communicators-practical

https://earth.org/statistics-about-fast-fashion-waste/

https://www.greenpeace.org.uk/news/the-uks-fast-fashion-habit-is-getting-worse-and-its-destroying-the-planet/

https://carbonliteracy.com/climate-change-fashion-waste-colonialism/

https://theconversation.com/new-research-nitrous-oxide-emissions-300-times-more-powerful-than-co-are-jeopardising-earths-future-147208

https://www.thedigitalhive.io/sustainability/polyester-and-nylon

https://www.europarl.europa.eu/topics/en/article/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographics

https://www.frontiersin.org/journals/environmental-science/articles/10.3389/fenvs.2022.973102/full?ref=csofutures.com

https://www.unep.org/news-and-stories/press-release/unsustainable-fashion-and-textiles-focus-international-day-zero
https://www.europarl.europa.eu/topics/en/article/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographics
https://unfccc.int/climate-action/sectoral-engagement-for-climate-action/fashion-charter
https://unfashionalliance.org/

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/42/0625

VERTICAL FARMING: INDOOR FARMING USING HYDROPONICS, AEROPONICS, AND LED LIGHTING TO GROW FOOD IN URBAN AREAS WITH MINIMAL RESOURCES

Kishor K. Anerao[1]*, Monali M. Joshi[2], Sachin A. Giri[3], Prasad S. Gangakhedkar[1], Radha M. Lolge[4] and Shaikh Ajaj[5]

[1]Ph.D. Scholar, Department of Food Microbiology and Safety, CFT, VNMKV, Parbhani (MS)
[2]Ph.D. Scholar, Department of Food Process Technology, CFT, VNMKV, Parbhani (MS)
[3]Ph.D. Scholar, Department of Food Engineering, CFT, VNMKV, Parbhani (MS)
[4]Ph.D. Scholar, Department of Food Business Management, CFT, VNMKV, Parbhani (MS)
[5]Ph.D. Scholar, Department of Food Chemistry and Nutrition, CFT, VNMKV, Parbhani (MS)
*Corresponding Email: Kishoranerao135101@gmail.com

Abstract
Vertical farming is an innovative urban agriculture system that involves growing crops in vertically stacked layers using soilless cultivation methods such as hydroponics and aeroponics, combined with LED lighting and controlled environmental conditions. This approach addresses key challenges of traditional farming, including limited arable land, water scarcity, and urban food insecurity. By enabling year-round crop production with minimal land and water use, vertical farming enhances food security and reduces transportation-related carbon emissions. However, challenges such as high initial investment, energy consumption, and technical expertise requirements hinder its widespread adoption. Advances in automation, renewable energy integration, and community training initiatives are essential for scaling this sustainable solution to future food demands.

Keywords: Vertical farming, hydroponics, urban agriculture, LED lighting, sustainable food production

Introduction

Vertical farming, an innovative approach to urban agriculture, utilizes hydroponics, aeroponics, and LED lighting to grow food in urban areas with minimal resources. This method addresses the challenges of limited land and resources in cities, offering a sustainable solution to food production. Vertical farming involves cultivating crops in vertically stacked layers within controlled environments, optimizing space and resource use. It holds the potential to enhance food security, reduce transportation costs, and minimize environmental impact. However, challenges such as high initial costs and energy requirements need to be addressed for widespread adoption. The following sections delve into the key aspects of vertical farming.

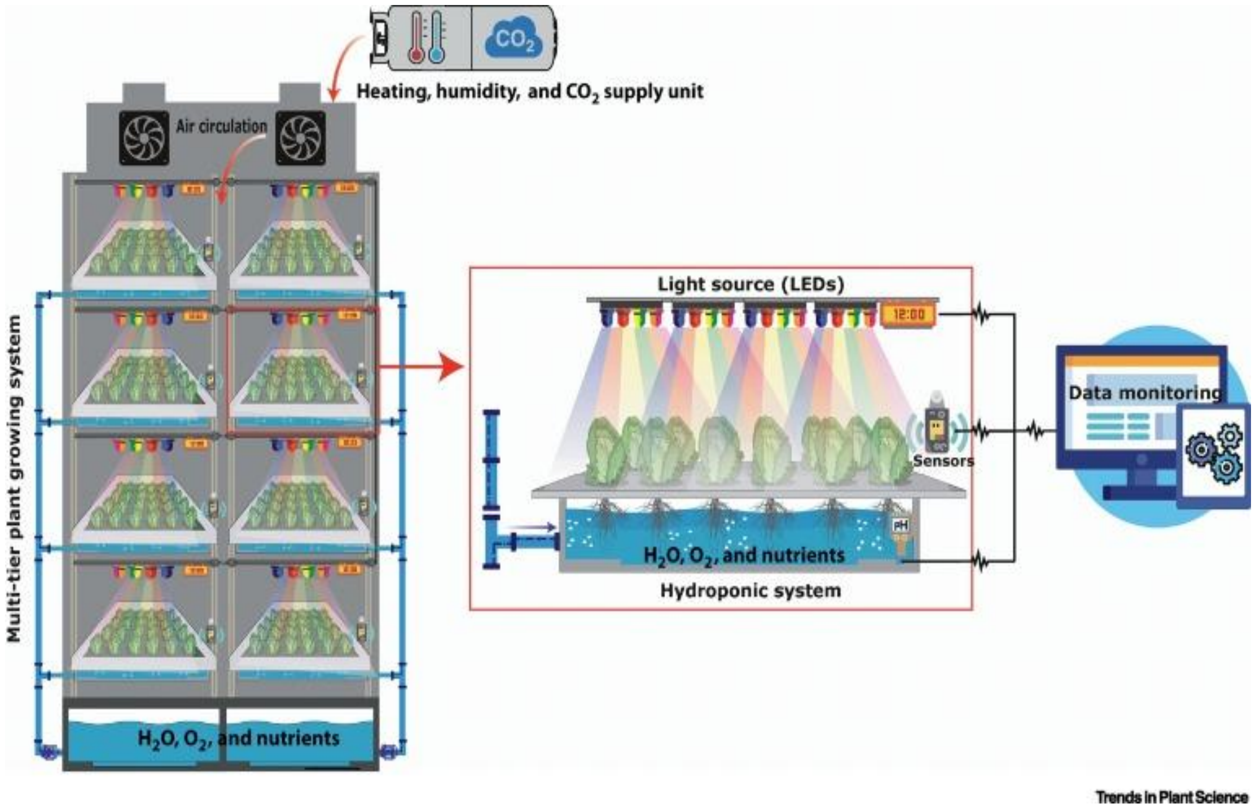
Techniques and Technologies

1. Hydroponics and Aeroponics

These soilless cultivation methods are central to vertical farming. Hydroponics uses nutrient-rich water solutions, while aeroponics involves misting plant roots with nutrient solutions. Both techniques significantly reduce water usage compared to traditional farming and allow for year-round crop production, maximizing space efficiency and minimizing the need for pesticides (Buragohain et al., 2024). These innovative approaches not only enhance crop yields but also contribute to sustainable agricultural practices by reducing the carbon footprint associated with transportation and land use. As urban populations continue to grow, the adoption of these soilless cultivation methods is becoming increasingly vital for meeting food demands in densely populated areas (Găgeanu et al., 2024). Furthermore, the closed-loop systems often employed in hydroponic and aeroponic setups allow for efficient recycling of water and nutrients, reducing waste and promoting environmental sustainability.

2. LED Lighting

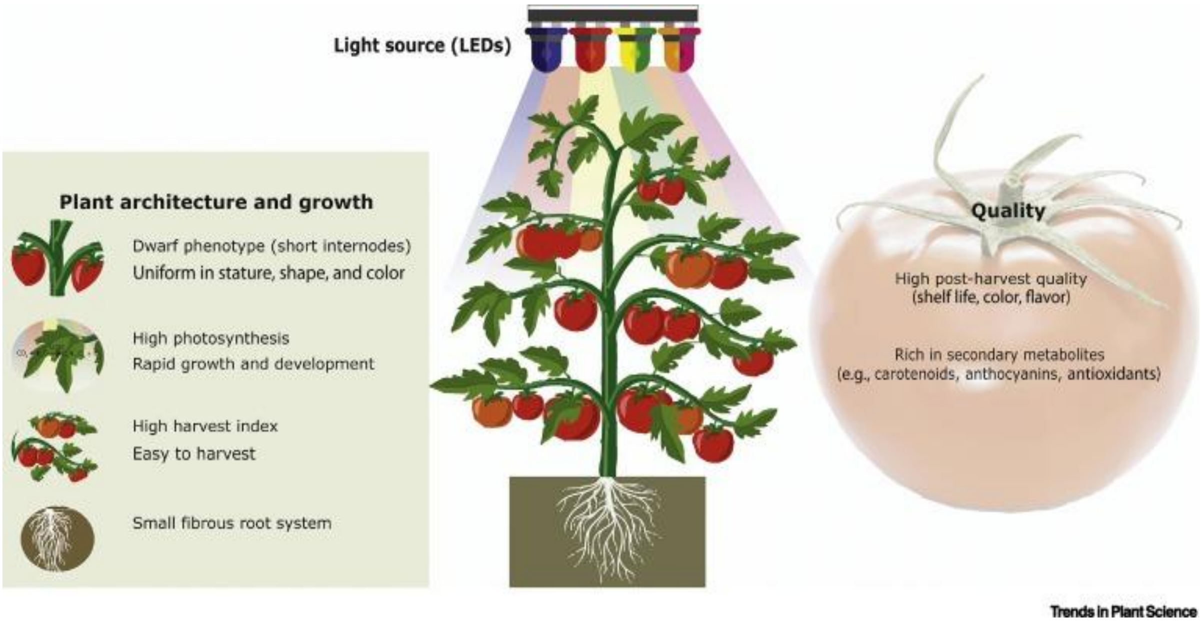
LED lights provide energy-efficient, customizable lighting conditions that support plant growth year-round, regardless of external weather conditions. This technology is crucial for maintaining controlled environments in vertical farms, where precise monitoring of temperature, humidity, and nutrient levels can lead to optimal crop health and productivity (Singh & Rai, 2024).The integration of automation and artificial intelligence in these systems further streamlines operations, allowing for real-time adjustments and data analysis that enhance overall efficiency and resource management (Găgeanu et al., 2024). Moreover, specific light wavelengths provided by LEDs can be tailored to promote different stages of plant growth, such as vegetative development and flowering, thereby improving both yield and quality of produce.



Source: (SharathKumar et al., 2020)

Figure 1: Set up of a Vertical Farm. A multilayer indoor plant growing system with an automated control system regulating the shoot environment (LED light, temperature, humidity, [CO2], air flow) and soilless root environment (EC, pH, concentration of nutrients and O2, and root temperature)

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter



Source: (SharathKumar et al., 2020)

Figure 2: Ideal Plant Phenotype with Desirable Attributes for Vertical Farming.

Advantages of Vertical Farming

i. **Efficient Land Use**: By stacking crops vertically, vertical farming maximizes land use efficiency, making it ideal for urban areas with limited space. (Buragohain et al., 2024). This innovative approach not only addresses food security challenges but also reduces transportation costs and carbon emissions, contributing to a more sustainable urban ecosystem (Singh et al., 2024).

ii. **Water Conservation**: Vertical farming techniques like hydroponics and aeroponics use significantly less water than traditional agriculture, addressing water scarcity issues and promoting sustainability (Găgeanu et al., 2024). As cities continue to grow and face challenges related to food security, vertical farming presents a viable solution by providing fresh produce locally, reducing transportation emissions, and minimizing the carbon footprint associated with conventional farming methods (Singh et al., 2024).

iii. **Reduced Transportation Costs**: By producing food within urban areas, vertical farming reduces the need for long-distance transportation, lowering carbon emissions and transportation costs (S et al., 2024). This innovative approach not only enhances food accessibility but also fosters community engagement by encouraging local participation in agriculture and promoting awareness of sustainable practices among urban residents (Singh et al., 2024).

iv. **Year-Round Production**: Controlled environments allow for continuous crop production, independent of seasonal changes, enhancing food security and providing a reliable source of fresh produce year-round (Singh & Rai, 2024). This adaptability not only supports local economies but also contributes to the resilience of urban food systems in the face of climate change and other environmental challenges (Gokul & P.S, 2016).

Challenges and Limitations

i. **High Initial Costs**: The setup of vertical farms requires significant investment in technology and infrastructure, which can be a barrier to entry for many aspiring entrepreneurs and small-scale farmers. However, the long-term benefits include increased crop yields, reduced water usage, and the ability to grow food in urban areas, making it an attractive option for sustainable agriculture (Buragohain et al., 2024). As urban populations continue to rise, the demand for locally sourced food will likely increase, further incentivizing the development of vertical farming systems that can efficiently meet this need (Panotra et al., 2024).

ii. **Energy Consumption**: Maintaining controlled environments and artificial lighting can lead to high energy costs, necessitating the integration of renewable energy sources (Singh et al., 2024). By adopting solar panels and other green technologies, vertical farms can mitigate these costs while enhancing sustainability, ultimately contributing to a more resilient food system in densely populated regions (Gokul & P.S, 2016).

iii. **Technical Expertise**: The operation of vertical farms requires specialized knowledge and skills, which may not be readily available in every community. Therefore, investing in education and training programs will be crucial to equip individuals with the necessary expertise to manage these innovative agricultural practices effectively ("Investigating the potential of vertical farming and indoor agriculture for sustainable food production in urban areas", 2023) (Panotra et al., 2024).

Economic and Social Implications

- **Job Creation**: Vertical farming can create new employment opportunities in urban areas, contributing to local economies and fostering a sense of community engagement through the promotion of sustainable practices and local food production (Panotra et al., 2024).
- **Food Security**: By increasing local food production, vertical farming can enhance food security in urban areas, reducing reliance on imported food and minimizing the carbon footprint associated with transportation. This approach not only addresses immediate food needs but also encourages a shift towards more sustainable consumption patterns, ultimately leading to healthier communities and environments (Singh & Rai, 2024) (Singh et al., 2024).

Conclusion

Vertical farming presents a promising solution to urban agriculture challenges, it is not without its drawbacks. The high initial investment and energy costs pose significant barriers to widespread adoption. However, ongoing research and technological advancements aim to address these challenges, making vertical farming a viable option for sustainable urban food production. Collaborative efforts among researchers, policymakers, and industry stakeholders are essential to overcoming these obstacles and realizing the full potential of vertical farming in promoting environmental sustainability and food security.

References

Buragohain, R., Hazarika, B. N., Deka, B., Devi, S., & Bathari, M. (2024). Vertical Farming: A Promising Solution to Urban Agriculture. *International Journal of Environment and Climate Change*. https://doi.org/10.9734/ijecc/2024/v14i104476

Găgeanu, I., Tăbărașu, A.-M., Persu, C., Gheorghe, G., Niţu, M., Cujbescu, D., IONESCU, A., & ANGHELACHE, D. (2024). Hydroponic vertical systems: enhancing climate resilience, water efficiency, and urban agriculture. *INMATEH-Agricultural Engineering*. https://doi.org/10.35633/inmateh-73-08

Gokul, A. J. A., & P.S, S. (2016). Vertical Farming: a novel farming technology. *International Journal of Modern Trends in Engineering and Research*.

Panotra, N., Belagalla, N., Mohanty, L. K., Ramesha, N. M., Vikash, ., Tiwari, A., Abhishek, G. J., Gulaiya, S., Yadav, K., & Pandey, S. K. (2024). Vertical Farming: Addressing the Challenges of 21st Century Agriculture through Innovation. *International*

SharathKumar, M., Heuvelink, E., & Marcelis, L. F. M. (2020). Vertical Farming: Moving from Genetic to Environmental Modification. *Trends in Plant Science*, *25*(8), 724–727. https://doi.org/10.1016/j.tplants.2020.05.012

Singh, N. K., & Rai, A. K. (2024). Redefining Sustainable Agriculture for the 21st Century by Vertical Farming. *Journal of Scientific Research and Reports*. https://doi.org/10.9734/jsrr/2024/v30i51967

Singh, S., Singh, P., Kumar, A., Baheliya, A. K., & Patel, K. K. (2024). *Promoting Environmental Sustainability Through Vertical Farming: A Review*. https://doi.org/10.9734/jabb/2024/v27i5780

S, V. V., Sushma, N. J., Tilak, K. V. B. R., & A.R, M. (2024). *Vertical farming for future food requirement – problems and prospects*. Volume 3, May, 2024, Page no.110-118, https://doi.org/10.58532/v3bcag12p1ch12.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 05/VI/43/0625

CONCEPT OF CONTROLLED TRAFFICKING FARMING SYSTEMS IN INDIA

Maheshwari[1*], Sunil Shirwal[2], Abhishek[1] and Satish[1]

[1]PhD Research Scholar, Department of Farm Machinery & Power Engineering, University of Agricultural Sciences, Raichur, Karnataka 585104
[2]Associate Professor, Department of Farm Machinery & Power Engineering, University of Agricultural Sciences, Raichur Karnataka 585104
*Corresponding Email: mahipatil245@gmail.com

Abstract
Traffic induced soil compaction, as well as the associated negative effects on soil structure and soil functions can be reduced by the use of permanent traffic lanes for all field vehicles – known as Controlled Traffic Farming (CTF). Annett *et al.*,2019 .The world is currently facing many challenges includes ensuring food security, minimizing environmental damage, and ensuring sustainable agriculture production. About 68 million ha of land worldwide has been affected with soil compaction which could rise potentially in the coming years. Rashmi *et al.*, 2019. As the farmers are facing many challenges such as water scarcity, soil degradation, and climate change. Controlled trafficking farming system is a management tool which is used to reduce the damage to soils caused by heavy or repeated agricultural machinery passes on the land. This system mainly occurs in large scale land holdings and can be reduced by some agronomical methods like conservation tillage, crop rotation, sub soiling and growing cover crops.

Keywords: Controlled Trafficking Farming, Soil compaction and traffic lanes

Introduction

CTF involves designating permanent traffic lanes for farm machinery, separating them from crop zones. This simple yet effective approach reduces soil compaction, promotes soil health, and increases crop productivity. It creates two zones, non-trafficked crop beds and cropped or non-cropped traffic lanes, both of which are optimized for their different functions. Disorganized or random traffic causes an increase in the bulk density of any given soil, which increases its strength and reduces its porosity (**Chamen *et al.*, 2010**). CTFS has gained attention in states like Punjab, Haryana, and Uttar Pradesh, where intensive agricultural practices and large-scale farming are common. Adoption of such systems has also been explored in other states with issues related to soil health and water management.

Benefits of Controlled Traffic Farming

The main benefit of controlled traffic farming is to reduce soil compaction which is mainly caused in large land holdings where a huge use of heavy farm machinery. This leads to decreased soil health affecting crop yield and crop growth. There are some of the benefits of controlled traffic farming listed below;

Reduced Soil Compaction: By confining traffic to specific lanes, CTF minimizes soil compaction, preserving soil structure and promoting healthy root growth.

Increased Crop Yields: With reduced soil compaction and improved soil health, crops grow stronger and more resilient, leading to increased yields.

Improved Soil Health: CTF promotes soil biota, organic matter, and water infiltration, creating a more sustainable and productive soil ecosystem.

Reduced Fuel Consumption: By optimizing machinery use and reducing soil compaction, CTF can lead to significant fuel savings.

Besides CTF systems, soil compaction can be reduced by loosening the soil using subsoiler once after every 4-5 years and planting deep rooted corps. Sub-soiling is done in compacted soils with hardpans or compacted layers that restrict root growth and soils with poor drainage, leading to waterlogging or erosion. Deep-rooted crops: Crops with deep root systems, like alfalfa or corn that benefit from improved subsoil conditions. Sub-soiling may not be effective in all soil types, such as sandy soils and is most effective when soil is relatively dry. Specialized equipment, like subsoilers or deep rippers, is required. Cover crops are plants grown between crop cycles to protect and enhance the soil. Examples: Winter Cover Crops like Winter rye, Hairy vetch, Clover Various types, like red clover or white clover, offer nitrogen fixation and soil benefits. Summer Cover Crops like Buckwheat, Sorghum-Sudan grass, Cowpeas.

Cover Crops have so many benefits including soil erosion control to protect topsoil from wind and water erosion, soil health improvement which adds organic matter, improves structure, and increases fertility. Weed suppression outcompetes weeds for resources, reducing herbicide use, pest and disease management which attracts beneficial insects and reduces pest pressure and helps mitigate climate change impacts by sequestering carbon and improving soil water-holding capacity. The figure 1 shows the effects of heavy farm machinery on soil properties and traffic ability.

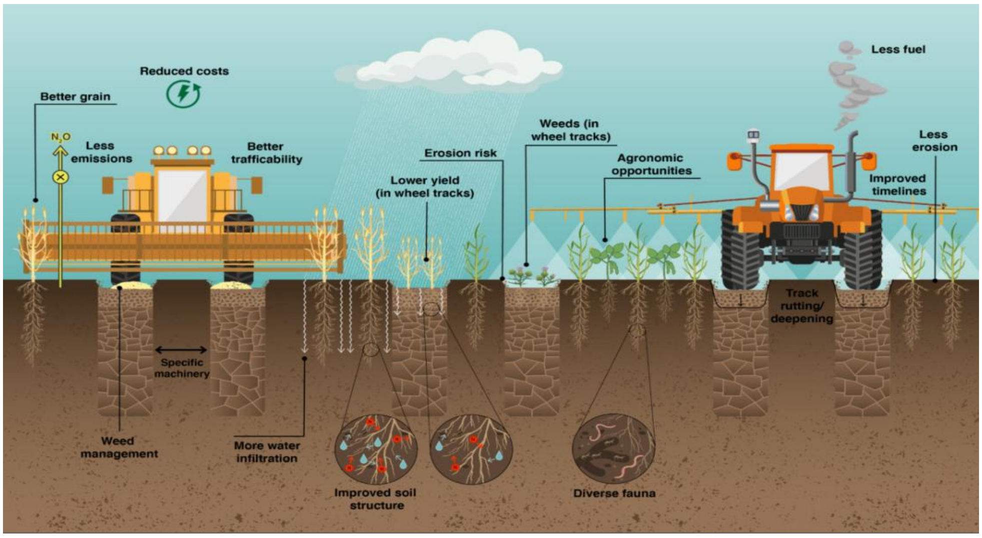


Fig 1.Effects of Controlled Traffic Farming in Field

Methods to adopt Controlled Traffic Farming System

There are some steps to achieve controlled traffic system While CTF offers numerous benefits, implementing it require careful planning and investment, farmers should:

Designate Traffic Lanes: Identify permanent traffic lanes, typically using GPS guidance, to ensure accurate and consistent machinery movement.

Separate Crop Zones: Divide the farm into crop zones, each with its own specific management practices, to optimize crop growth and reduce soil compaction.

Adapt Machinery: Modify farm machinery to fit within designated traffic lanes, minimizing soil compaction and reducing crop damage.

Assess Soil Conditions: Evaluate soil type, moisture levels, and compaction to determine the best CTF approach.

Invest in Guidance Systems: Utilize GPS guidance and auto-steering systems to ensure accurate machinery movement.

Match implement widths so that adjacent passes are in the same place for all machines working in the field.

Match the track widths (the distance between wheel centers on the same axle) of all field machinery and keep machines in exactly the same place year in year out.

Achieve tramlines and using RTK positioning systems.

Traffic lanes or tramlines are the specific machinery pathways in the field which is shown below

Fig 2. Tramlines

Methods to reduce soil compaction

There are many agronomical methods to reduce traffic induced soil compaction which includes conservation tillage, growing cover crops like Buckwheat, Sorghum-Sudan grass, Cowpeas, crop rotation and sub soiling one after every 4-5 years in the field. Some are given below in Fig 3.

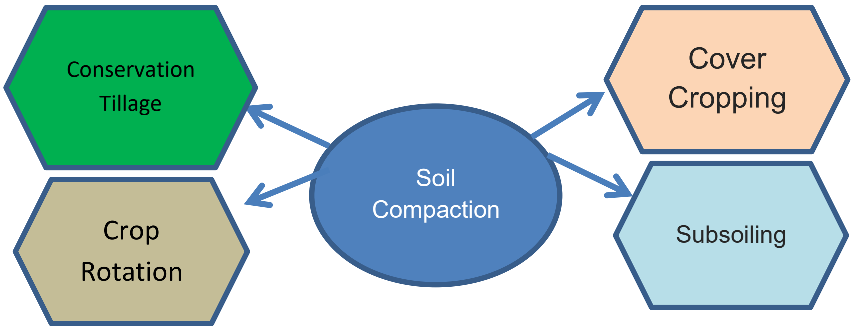


Fig 3. Methods to reduce soil compaction

CTF Calculator as a planning tool

Matching machinery width and tracks to establish a controlled traffic farming system can be a daunting prospect, particularly where current machinery is of variable dimensions. The 'CTF Calculator' is a useful web-based tool that can assist farmers and their consultants with machinery investment planning. The calculator estimates the percentage area of the paddock that is 'wheeled' by different machinery combinations, and calculates the estimated areas impacted and thus the benefit of managing compaction through the adoption of controlled traffic farming. Users enter their current machinery specifications into the calculator for each farming operation – for example, seeding tractor, air cart and bar, or spreading tractor and spreader to determine the area wheeled for each farming operation, and an overall combined wheeled percentage for all operations over the season.

Users can choose to select from a library of pre-loaded machinery options, or specify their own current tyre size, track gauge (i.e. tyre centre to centre dimension) and operating width. The user can then compare various combinations of proposed new and modified machinery to match track gauges and reduce wheeling percentage in the calculator.

Conclusion

Controlled trafficking farming systems can be an effective strategy for improving sustainability in Indian agriculture, enhancing soil health, and conserving water. However, it requires appropriate investment, training, and infrastructure for broader adoption. This system can be adopted in large land holdings where heavy machineries are used which cause soil compaction. CTFS has gained attention in states like Punjab, Haryana, and Uttar Pradesh, where intensive agricultural practices and large-scale farming are common. Adoption of such systems has also been explored in other states with issues related to soil health and water management.

References

Bangle R. 2019, Controlled Traffic Farming: A Sustainable Solution to Soil Compaction. Acta Scientific Agriculture. ISSN: 2581-365, 7 (2)

Boulal, H., Gómez-Macpherson, H., Gómez, J.A. & Mateos, L., 2011. Effect of soil management and traffic on soil erosion in irrigated annual crops. *Soil and Tillage Research*, 115, 62-70

Chamen, T., 2015. Controlled traffic farming–from worldwide research to adoption in Europe and its future prospects. *Acta Technologica Agriculturae*, 18(3), 64-73.

Latsch A.. Anken T,. 2019. Soil and crop responses to a "light" version of Controlled Traffic Farming in Switzerland. Soil and Tillage Research ,pp 104310

Shubha, K., Singh, N.R., Mukherjee, A., Maity, A. & Dubey, R., 2020. Controlled traffic farming. *Current Science*, 119(11),1760-1766.

Official Address :
Peshok Tea Estate
P.O.- Peshok, Dist.- Darjeeling
West Bengal, India
PIN-734312

Contact No : +91 9635231406
email : agriindiatoday@gmail.com