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From the Editors Desk

I am pleased to announce the second issue of AgriTech Today, an English e-Magazine dedicated to publish popular articles of Agriculture and allied Sciences. The purpose of the magazine is to provide a platform for the academicians, researchers, Post Graduate students, research scholars etc to express their view on their specialization.

The technology has driven the reading habits of the people. The e-version of the magazine is more accessible and has the ability to reach to maximum extent. The magazine is a must-read for anyone interested in the future of agriculture and the role that technology will play in shaping it. The AgriTech Today Magazine is a welcomed addition to the industry, providing valuable insights and information about the latest developments in Agriculture sector. In this issue, fifteen articles are reviewed and published in different topics.

The magazine is a must-read for anyone interested in the future of agriculture and the role that technology will play in shaping it.

I whole heartedly thank Dr. Sreenivas Reddy sir for appreciating and encouraging us to continue good work. I also extend my thanks to the editorial team and authors for their contribution in bringing up this issue.

Editor-in-chief

Message

Agriculture is a profession and practice adopted by different stakeholders of farming community in the country more so in our southern states. It consists of not only crops, but also livelihood systems and their management for achieving the sustainable production and productivity in terms of access to food, availability of food, nutrition, water without affecting environment and its quality.

The weather and its aberrations due to its uncertainty jeopardize the entire production cycle of livelihoods in the farming community and more so due to the impact of climate change which is happening. The whole agriculture and its management from seed to product has become a game theory where one can succeed or fail. To address this kind of situation, we need to establish the integrated information system with technological options/ solutions to the farmers through ICT modules and their dissemination to farmers is the utmost importance in the present days agriculture development of the country. In view of this, starting of AgriTech Today e magazine to disseminate the information to the farming community is timely and right step in the service of the farmers. I congratulate the entire editorial team and publishers of the magazine for taking forward of the objectives and solutions to problems of the farmers in the country or within southern states.

Wishing You all the best.

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Civilization as it is known today

could not have evolved nor

can it survive, without

an adequate food supply

- Norman Borlaug

MICROGREENS: TREND TOWARDS SUSTAINABLE AGRICULTURE

Shivangi Bishnoi, Jayanti Tokas, Komal and Geeta Bishnoi

Due to the interest of society in healthy eating over the past twenty years, there has been an increase in demand for fresh, functional, and nutraceutical foods (Ebert 2012). The recent Covid 19 pandemic caused agricultural systems to struggle with the problem of food insecurity in many regions of the world. Further, there is a higher demand for less processed and fresh greens as food offered by urban agriculture (UA) (Lal 2020). As a result, urban agriculture (UA) has recently gained a lot of attraction as it is recognised as an important tool for maintaining local food security as well as for generating income and employment in urban areas. Microgreens production is an important part of urban agriculture (Paraschivu et al. 2021; Pulighe et al. 2020). Microgreens, also called 'vegetable confetti', are tender immature greens that can be produced from the seeds of vegetables, grains or herbs, including their wild species (Xiao et al. 2012). Their popularity stems from fortified phytonutrient content, potential bioactive value and other quality attributes (such as their vivid colors, delicate textures, unique flavor enhancing properties as garnishes) (Sun et al. 2013, Xiao et al. 2015, 2012). Microgreens are the young leafy greens during cotyledon growth stage when the first couple of true leaves appear (7–14 days after sprouting, depending on the species) (Du et al. 2022). Mostly exploited species belongs to the families of Chenopodiaceae, Apiaceae, Amarillydaceae, Asteraceae, Amaranthceae, Lamiaceae, Cucurbitaceae and Brassicaceae (Andrejiova et al. 2017).

Microgreens can be produced on a big scale in industries for commercial selling, or on a small scale by individuals at home. Microgreens quality is considerably affected by their growing, harvesting and post-harvest handling (Stoleru et al. 2016). Currently, microgreens at large scale are produced in greenhouse that helps to avoid the impact of environmental pollution, making them available throughout the year (Zhang et al. 2021). Microgreens are suitable crops for indoor and greenhouse cultivation, as they require negligible input (such as fertilisers) considering their short growth period. Various soil substitutes (such as vermiculite, coconut fibre, jute fabric and peat-based media) have been explored as new growth substrates to enhance nutritional quality of microgreens and sprouts (Muchjijab et al. 2014). The suitability of these soil substitutes is determined by various attributes including their water holding capacity, bulk density, particle density, air capacity, and total pore space (Sharma et al. 2022). The effects of culture substrates on the nutritional values vary with the species of microgreens. Hydroponics is modern planting technology used widely in urban agricultural production as it could avoid the transmission of pests and diseases through the growth media to the plants. In addition, hydroponics has been applied to improve growth and nutritional content in microgreens by fertigation with nitrogen and calcium (Li et al. 2021).

Nutritional composition

Microgreens have potential role as anti-inflammatory, anti-carcinogenic, anti-obesogenic and anti-atherosclerotic and are therefore popular as functional food of the 21st century (Fuente et al. 2019). The microgreens have abundant bioactive compounds such as vitamins, minerals and phytochemicals as examined in many research studies. Also, the nutritional value and phytochemicals content of vegetables and other crops may vary with plant growth and development (Zhang et al. 2021). Generally, the concentration of essential minerals, vitamins, bioactive compounds, and antioxidant activity is

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found to be higher in microgreens as compared with their sprouted or raw seeds (Gioia et al. 2017). Examples of variations of the content of essential nutrients, vitamins, and phytochemicals are discussed below.

Kowitcharoen et al. (2021), studied the carbohydrate profile of 14 different microgreens from Brassicaceae, Pedaliaceae, Malvaceae, Fabaceae and Convolvulaceae were examined, and mungbean (7.16 g 100 g^{-1}) showed the highest content followed by fenugreek (5.12 g 100 g^{-1}). For the rest, the total carbohydrate content ranged from 2.32 to 4.90 g 100 g^{-1}. The protein content among 10 different microgreens ranged from 1.8 to 4.4 g per 100g (Ghoora et al. 2020). According to Paradiso's study, the protein content is higher in Brassicaceae microgreens (broccoli) in comparison to the Asteraceae (chicory) varying between 1.9 to 3.0 g per 100 g. Pajak et al. (2014) and Khang et al. (2016) showed increase in total phenolic content (TPC) and antioxidant activity of mungbean, adzuki bean, black bean, soybean, peanut, radish, broccoli and sunflower upon germination. The seed-storage compounds are broken down during the germination process leading to the synthesis of structural proteins and other cellular components (Mishra et al. 2021).

Microgreens are found to be rich in vitamins (e.g., vitamin C, tocopherol and β-Carotene), minerals (*viz.* copper and zinc), phenolic compounds and phytochemicals, which act as antioxidants in human body (Zhang et al. 2021). Ascorbic acid (vitamin C), β-Carotene (provitamin A) and tocopherols are the fat- and water-soluble vitamins that act as antioxidants protecting the cellular damage by free radicles scavenging activity (Singh et al. 2006). Phylloquinone (vitamin K_1), on the other hand is required for blood coagulation in the human body (Ramirez et al. 2020). Xiao et al. (2012) determined the concentrations of ascorbic acid, carotenoids, phylloquinone, and tocopherols in 25 commercially available microgreens. β-carotene levels ranged from 0.6 to 12.1 mg/100 g being highest in red sorrel (12.1 mg/100 g) and lowest in golden pea (around 0.6 mg/100 g). Red cabbage (147.0 mg/100 g) microgreens showed 6 times higher ascorbic acid content and 40 times higher tocopherol content than their mature counterpart (24.4 mg/100 g; 0.06 mg/100 g, respectively) (Singh et al., Podsedek et al. 2006). High content of α- and γ-tocopherol were detected in green radish (87.4 and 39.4 mg/100 g, respectively) while for other microgreens the range of α-tocopherol varied from 41.2 to 53.1 mg/100 g. Among the 25 microgreens assayed, the highest concentration of phylloquinone was observed in garnet amaranth (4.1 μg/g), followed by red sorrel (3.3 μg/g), green basil (3.2 μg/g), pea tendrils (3.1 μg/g), and red cabbage (2.8 μg/g) microgreens. Generally, green (pea) or bright red (amaranth) coloured microgreens were found rich in phylloquinone content were generally green (e.g., pea tendrils) or bright red in colour (*viz.* garnet amaranth microgreens), while light-coloured microgreens (golden pea) depicted relatively low concentration (Bolton-Smith et al. 2000).

Polyphenols are another group taste and color providing antioxidants in the human diet. They are found abundantly in plants as secondary metabolites. Microgreens have varied number of polyphenols varying among different species (Xiao et al. 2015). Due to the antioxidant activity microgreens can help to avoid several diseases like cancer, diabetes and heart disease (Ramirez et al. 2020). Thirteen different microgreens species representing Brassicaceae, Chenopodiaceae, Lamiaceae, Malvaceae and Apiaceae family were evaluated for phenolic content using LC–MS. Total phenolic content differed significantly across microgreens species ranging from 691 mg kg^{-1} to 5920 mg kg^{-1}. Twenty-eight phenolic compounds were variably detected and quantitated in the 13 microgreens species examined.

Flavonol glycosides, flavones and flavone glycosides and hydroxycinnamic acids represented 67.6%, 24.8% and 7.6% of the mean total phenolic content (Kyriacou et al. 2019). Several strategies have been used to enhance phenolic content in microgreens such as the application of (Light-emitting diode) LED light, utilization of salinity stress and selenium biofortification. The transcription level of phenolic biosynthesis genes increased on illumination with blue light and UV-A for soybean microgreens (Zhang et al. 2019). Red and blue light treatment in green basil microgreens enhanced the gallic acid and rosmarinic acid content by 4 and 15 folds, respectively (Lobiuc et al. 2017). Also, phenolic acid and flavonoid in the wheat microgreen extract increased significantly by application of NaCl (12.5mM) (Islam et al. 2019). Further, selenium biofortification (16 μM) increased the total phenolic content by 21% in coriander microgreens (Pannico et al. 2020).

In mineral composition of three different microgreens chicory, lettuce and broccoli the most abundant was K and Ca followed by P and S. Lettuce microgreens had considerably higher contents of P, Ca, Mg and Zn (872 mg kg^{-1}, 1466 mg kg^{-1}, 248 mg kg^{-1} and 5.2 mg kg^{-1}, respectively) than mature lettuce butterhead (330 mg kg^{-1} P, 350 mg kg^{-1} Ca, 130 mg kg^{-1} Mg, and 2 mg kg^{-1} Zn) (Paradiso et al. 2018). Lettuce microgreens possessed higher mineral content (Ca, Mg, Fe, Mn, Zn, Se, and Mo) and lower nitrate content than mature lettuce (Pinto et al. 2015). Although the microgreen species has higher minerals then their mature form, still some (such as Fe and Zn) are not adequate to meet the RDA value (Gude et al. 2019). Therefore, biofortification of microgreen is new trend adopted for enhanced mineral content. The biofortification (Zn and Fe) of Brassicaceae microgreens was tested on arugula, red cabbage, and red mustard microgreens. Zn content enhancement in microgreens was observed (ranging from 75% to 281%) at 5 and 10 mg L^{-1} of zinc sulfate solution. On the other hand, iron enhancement (64% in arugula and 278% in red cabbage) was observed at 10 and 20 mg L^{-1} of iron sulfate (Gioia et al. 2019).

Conclusion

Microgreens are widely recognised functional foods as they are beneficial to human health due to their high levels of minerals, vitamins, polyphenols and antioxidative compounds. Several ways have been explored to enhance the nutritional content of microgreens such as biofortification (Se, Zn, Fe and others), use of different substrates (vermiculite, coconut fibre, and jute fabric) and LED light application. Hence, microgreens proved to have high research potential and help in coping with the food security and hidden hunger problem. There are still variety of wild species that need to be explored in terms of their nutritional value. Microbial contamination in microgreens is a major drawback leading to the nutrition exploitation. Several pre and post-harvest handling strategies could help to extend the shelf life of microgreens.

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WASTE TO WEALTH: CONVERSION OF BIOMASS INTO SUSTAINABLE ENERGY

Rinju Lukose, S. R. Kalbande and Prajakta Phadtare

Biomass is a renewable energy source that is derived from organic matter, such as plants, animals, and agricultural waste. This energy source is considered renewable because it comes from living organisms that can be regrown or replenished, unlike fossil fuels which are finite resources. Biomass can be used to produce heat, electricity, and transportation fuels and is seen as a promising alternative to traditional fossil fuels. By utilizing the various types of biomasses, we can generate energy in a sustainable and environmentally friendly way. As per a recent study sponsored by MNRE, the current availability of biomass in India is estimated at about 750 million metric tonnes per year. The study indicated estimated surplus biomass availability at about 230 million metric tonnes per annum covering agricultural residues corresponding to a potential of about 28 GW.

There are several advantages for using biomass as an energy source. For one, it is a carbon-neutral source of energy, meaning that the carbon emissions produced from burning biomass are offset by the carbon dioxide that is absorbed by the plants during their growth. This makes biomass a much cleaner energy source than fossil fuels, which emit large amounts of carbon dioxide and contribute to climate change. There are several types of biomasses, including:

Wood and wood waste: Wood is the most commonly used biomass material, and it includes everything from logs and branches to sawdust and wood chips. Wood can be burned to produce heat or electricity or used to create wood pellets that can be used in stoves or boilers.

Agricultural crops and waste: Biomass can also come from agricultural crops such as corn, soybeans, and wheat. The waste from these crops, including stalks and husks, can also be used as biomass. These materials can be used to produce biofuels such as ethanol or biodiesel.

Municipal solid waste: Organic materials in municipal solid waste, such as food scraps and yard waste, can be used as biomass to produce energy. This is often done through a process called anaerobic digestion, which breaks down the organic material and produces biogas.

Algae: Algae is a promising source of biomass because it grows quickly and can be cultivated in a variety of environments. Algae can be used to produce biofuels such as biodiesel or ethanol.

Animal waste: Animal waste, such as manure, can be used as biomass to produce energy. This is often done through anaerobic digestion, which produces biogas that can be burned to generate electricity or heat.

Biomass conversion technologies

Biomass can be converted into useful forms of energy using a number of different processes. Factors that influence the choice of conversion process are: the type and quantity of biomass feedstock, the desired form of the energy, i.e. end-use requirements, environmental standards, economic conditions, and project specific factors. In

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many situations the form in which the energy is required determines the process route followed by the available types and quantities of biomass. The conversion technologies to utilize biomass can be classified into two basic categories:

1. Thermo-chemical conversion
2. Bio-chemical conversion

Thermo-chemical conversion

In thermo-chemical conversion processes, energy is produced by applying heat and chemical processes. There are four thermos chemical conversion processes, i.e., combustion, pyrolysis, gasification, and liquefaction.

Combustion

Biomass combustion is the simplest thermo-chemical conversion technology that takes place in the presence of air. Heat, power, or CHP are the main products of direct combustion of biomass; this process consists of consecutive heterogeneous and homogeneous reactions. Biomass combustion essentially depends on the particle size and properties of the feedstock, temperature, and combustion atmosphere. High emissions of NOx, CO_2, and particulate matter, in addition to ash handling, make combustion environmentally challenging. Combustion can be split into four stages: (1) drying, (2) pyrolysis, (3) volatiles combustion, and (4) char combustion.

The products from biomass combustion are essentially similar to emissions from fossil fuel combustion. Carbon dioxide (CO_2) and water are the most abundant emissions because they are the products of complete combustion. Carbon monoxide (CO), hydrocarbons (HC), and particulate matter are associated with incomplete combustion and are highest for the least efficient combustion systems.

Pyrolysis

Pyrolysis is the conversion process of specific biomass into liquid (bio-oil), solid (charcoal), and gaseous (combustible gas) products through partial combustion at temperatures around 500 °C and in the absence of oxygen. High temperatures allow the vaporization of the volatile components of the biomass producing gases, whose vapours are condensed into liquids by liquefaction. The liquid fuel resulting from this process can be stored and subsequently used for various heating and electricity generation applications. In addition to liquid fuels, the pyrolysis process also produces other combustible products such as charcoal, gas, and many other value-added chemicals.

There are different ways of carrying out the pyrolytic process affecting the production of bio-oil, syngas and carbonaceous residues:

a) Carbonization, the most ancient and known pyrolysis process, occurring at temperatures between 300 and 500 °C. From this process, only a solid fraction (vegetable coal) is recovered.

b) Slow or conventional pyrolysis occurs at moderate temperatures around 500 °C, through which approximately three fractions are obtained in equal proportions. Slow pyrolysis requires longer reaction and transformation times than fast pyrolysis due to low temperature and heating values.

c) Fast pyrolysis takes place at medium-low temperatures (from 500 to 650 °C), in which the gasification reactions take place quickly and with short contact times, so that the intermediate compounds are reformed, bringing the production of the liquid fraction up to 70-80 wt.% of the incoming biomass. Generally, this type of pyrolysis produces 60% of bio-oil, 20% of bio-coal, and 20% of gas.

d) Flash pyrolysis is performed at temperatures higher than 650 °C with contact times of less than one second and favours the production of the gaseous fraction (efficiency reaching 80%).

Gasification

Biomass gasification is a thermal process which converts organic carbonaceous materials (such as wood waste, shells, pellets, agricultural waste, energy crops) into a combustible gas comprised of carbon monoxide (CO), hydrogen (H) and carbon dioxide (CO_2). This is achieved by reacting the material at high temperatures, without fully combusting it, using a controlled oxygen (O) inlet. The resulting gas mixture is called syngas. At temperatures of approximately 600 to 1000°C, solid biomass undergoes thermal decomposition to form gas-phase products which typically include CO, H, CH_4, CO_2, and H_2O.

Liquefaction

Liquefaction is a biomass conversion process conducted in water at moderate temperatures ranging between 280 to 370 °C and high pressures (10-25 MPa). A liquid bio granulates, similar to crude oil, as well as other gaseous, aqueous, and solid by-products are also generated. The obtained products have a high heating and a low oxygen content making it a chemically stable fuel. The main purpose of liquefaction is to obtain high H/C ratio oil. For this type of conversion, two processes, based on the raw materials used, are distinguished: lignocellulosic biomass (dry raw material) liquefaction and algal biomass (wet raw material) liquefaction. In both cases, the raw material requires a preliminary treatment, which consists in the removal of woody biomass contaminants along with obtaining a stable suspension, thereby reducing the size of the particles (through alkaline treatments) for easy pumping into reactors.

Principally, the most used process includes the use of lignocellulosic biomass processed at a temperature of about 350 °C and a pressure of 150 bar for about 15 min. Under these process conditions, a spontaneous phase separation takes place, generating a gaseous phase of CO_2, solid residues, biocrude, and a minor aqueous phase. The obtained solid phase material could be used directly as biofuel or fertilizer. The aqueous phase could be used inside the plant for processes requiring water or in anaerobic digestion. The bio-crude produced, which has a low oxygen content, requires further refining to be commercially exploited.

Bio-chemical conversion

Biochemical conversion processes allow the decomposition of biomass to available carbohydrates, which could be converted into liquid fuels and biogas, as well as different types of bioproducts, using biological agents such as bacteria, enzymes, etc. The most used biochemical technologies include anaerobic digestion and fermentation.

Anaerobic digestion

Anaerobic digestion is the conversion of organic material directly to a gas, known as biogas, which is a mixture of mainly methane and carbon dioxide with small quantities of other gases such as hydrogen sulphide. Organic non-lignocellulosic (non-woody) material, the feedstock (also known as substrate) is converted by microorganisms in the absence of oxygen. This conversion process produces stable and commercially useful compounds and is similar to composting except that composting is aerobic (involving oxygen) in its breakdown of organic matter. The biomass is converted by bacteria in an anaerobic environment, producing a gas with an energy content of about 20%–40% of the lower heating value (LHV) of the feedstock.

Anaerobic digestion is a commercially proven technology and is widely used for treating high moisture content organic wastes, i.e. 80%–90% m.c. Feedstocks for anaerobic digestion include organic wastes and residues (such as animal manures or slurry) or energy crops (such as maize silage) grown specifically for feeding the AD plant. Anaerobic digester produces conditions that encourage the natural breakdown of organic matter by bacteria in the absence of air. The two main products from an AD plant are biogas and digestate.

Fermentation

The fermentation process of organic materials consists of a series of biochemical reactions, converting simple sugars (hexoses and pentoses) into ethanol and CO_2, under anaerobic conditions by microorganisms mainly yeasts. The microorganisms commonly used to carry out the process are the Saccharomyces Cerevisiae, while the feedstock used for this type of process are categorized into three different classes: sugars, starch, and lignocellulosic substrates. In detail, the theoretical yield of the process is 51.14 g of ethanol and 48.86 g of CO_2, from 100 g of hexoses or pentoses. In addition to ethanol and CO_2, glycerol and carboxylic acids are also produced as by-products. The quality and yields of the process depend on various factors such as feedstock, temperature, pH, inoculum, and fermentation time.

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APICAL ROOTED CUTTING (ARC) TECHNOLOGY FOR RAPID POTATO SEED PRODUCTION

Riya Pandey and Swagat Ranjan Behera

India ranks second both in production and consumption of potato in the world. Potato is vegetatively propagated through seed tubers, which account for nearly half of the total cost of production. The conventional seed production technique through repeated use of tubers makes the crop susceptible to viral diseases and, therefore, leads to faster degeneration of the crop. Also, seed potato production in India is largely confined to the north and then it is transported to the potato-growing belts of the country, thus adding to high transportation costs. Of late, due to climate change, there has been a shift in the time of seed potato planting due to delayed paddy harvesting, which makes the crop more prone to insects and diseases and thus, leads to decreased production of reliable potato seed.

Challenges faced by farmers in acquiring good quality seed

1. Less area under potato cultivation
2. Poor quality seed
3. Huge transportation cost
4. Limited access of farmers to good potato varieties
5. Long time required to multiply any new variety
6. Exploitation by the local seed traders
7. Seed price is always unpredictable and high

There is, therefore, an urgent need to revive the potato sector through decentralising seed production areas and developing alternate seed system which ensures good quality seeds at affordable prices to farmers. Apical rooted cuttings (ARCs) could serve as a simple, effective and low-cost alternative to this problem.

What is Apical Rooted Cutting (ARC)?

Apical cuttings are rooted transplants produced from tissue culture plantlets in a screenhouse. Instead of allowing tissue culture plantlets to mature and produce mini-tubers, cuttings are produced from the plantlets. Apical cuttings are an alternative to mini-tubers in current production seed systems for potato.

How ARC technology work?

1. Procurement of disease-free mother cultures (from CPRI) and their *in vitro* multiplication in TC lab

2. Multiplication of mother plants in polyhouse

3. Production of ARC (seedlings) in polyhouse

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4. Seed production (Season 1) in open field

5. Seed production (Season 2) in open field

6. Commercial potato production

Table 1: Conventional vs ARC seed production technology

Particulars	Conventional seed production	ARC seed production
Investment	Cost intensive	Low cost
Technology	Complicated	Simple
Suitability	For only large-holding resource-rich farmers	Even small farmers can become seed producers
Gestation period	At least six seasons are required	Only two seasons
Risk	High	Low
Scope for expansion	Low	High
Seed system	Centralised	Decentralised

Conclusion

Once planted in the field, an apical cutting produces 10 to 25 or more seed tubers, compared to 5 to 10 seed tubers per mini-tuber at low cost. Given the high productivity of rooted apical cuttings, it is economical for multipliers to sell quality seed after two seasons of field multiplication, and after three seasons, it is highly profitable. It takes a multiplier who starts with mini-tubers, a minimum of six months to produce a commercial crop of seed tubers, whereas those who start with rooted apical cuttings produce a crop within two or three months. Using cuttings as starter material for seed production reduces the time taken to produce commercial seed by one year compared to minitubers, boosting the profitability of seed multiplication and the supply of quality seed available for farmers.

The benefits of seed potato production using ARC technology can be summarised as follows:

1. Farmers can manage decentralized local seed production.
2. Saving 'Seed Miles' - Local seed production avoids transportation of large volume of seeds from long distances and thus, minimizes cost of production.
3. Additional employment generation through seed production.
4. More returns to farmers and seed growers
5. Availability of desired seeds locally.
6. Strengthened 'Seed Potato Value Chain'.

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FILM FARMING: THE FUTURE OF AGRICULTURE

Anusree Sobhanan and Rekha Kumari Meena

The agricultural sector has significantly changed due to advancements in new technology. Traditional practices cannot withstand the upcoming climate crisis and future food security issues. It is no longer feasible to rely solely on traditional practices to address the imminent challenges of climate change and food security. Agriculture is the biggest consumer of water compared to any other sector accounting for 70% of global water usage and its use is often inefficient. To encounter the requirements of an emerging population, the demand for water is projected to increase by 15% by 2050. In the year 2000, approximately 22% of water depletion was attributed to irrigation water use, but this number is expected to decrease by almost 20% by 2050. In order to sustain the world population which is estimated to be 8.9 billion in 2050, there needs to be a 70% increase in food production. The most effective strategies for mitigating this issue involve improving irrigation efficiency and developing technologies for water and soil conservation. Several practices exist to utilize water and other resources in a more efficient manner, and numerous technologies are being developed to tackle the challenges of climate change and food insecurity in agriculture. This article highlights the application of film farming that uses hydrogel technique for crop cultivation.

Mori Yuichi (right) holding hydrogel film-grown plant

Film farming

Film farming is a new technology that uses hydrogel membrane as the growing medium in place of conventional soil. It is also known as IMEC (Intelligent Membrane Culture) that uses membrane and hydrogel Technologies. Here plants are grown on a transparent film (hydrogel film) which serves as the growing medium for plants.

Hydrogel is the key component in film farming system. These are polymeric substance that expands as they absorb water, and can retain a substantial amount of water within their structure without dissolving in water. It consists of monomer linked with crosslinkers. Hydrogels contain hydrophilic groups that allow them to absorb water and the cross links in hydrogel prevent them from dissolving in water. Hydrogel consist of polymers linked through crosslinks, widely used polymers includes sodium or potassium salt of acrylic acid. Hydrogels can be classified based on source,

Natural hydrogel – made from natural polymers, polysaccharides, proteins, etc.

Synthetic hydrogels – petrochemical origin, produced from acrylic monomers

Hydrogels are becoming increasingly popular in the field of agriculture due to their versatile applications, such as serving as water-absorbing materials, soil conditioners, fertilizer-releasing agents, and seed coatings. Hydrogels have the ability to retain water and fertilizer for extended periods and release them gradually to plants, and this property depends on chemical composition. When hydrated, hydrogel forms an amorphous gel-like mass. As the surrounding

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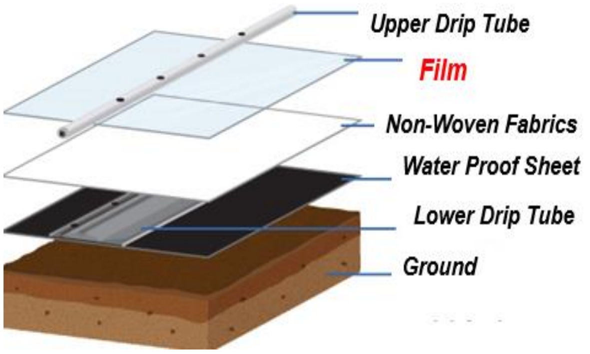
soil around the root zone of plants begins to dry up, the hydrogel releases water and nutrients due to osmotic pressure difference. This creates a reservoir of



Structure of IMEC system

water near the root zone, which helps in plant growth and development. The ability of hydrogels to retain water and release it gradually to plants can improve irrigation and water use efficiency, as it reduces the frequency of watering needed and minimizes water loss due to evaporation or leaching. In addition, it improves the texture, aeration and microbial activity of the soil.

Table 1: Hydrogels from natural and synthetic sources

natural polymer hydrogels	Synthetic polymers Hydrogels
Cellulose based hydrogels	Poly(ethylene glycol) (PEG) and Poly(ethylene glycol) (PEG)
Dextran hydrogels	Poloxamer 188 and Poloxamer 407 Hydrogels
Alginate hydrogels	Poly (hydroxyethyl methacrylate) PHEMA Hydrogels
Chitosan based hydrogels	Polyacrylamide (PAAm) Hydrogels and its Derivatives
Hyaluronic acid hydrogels	Polyvinyl alcohol (PVA) Hydrogel

IMEC System

Film farming was developed by Mori Yuichi through his start up Mebiol based in Japan, established in 1995. After successfully developing cherry tomatoes using film farming in Japan, Mebiol is now conducting research on other crops and seeking to expand its venture worldwide. Recently, they have been granted many patents from different countries. Strawberry, cucumber, capsicum, and lettuce have been successfully cultivated through film farming practices.

The IMEC system utilizes combination of hydrogel and membrane Technology. The whole system consists of

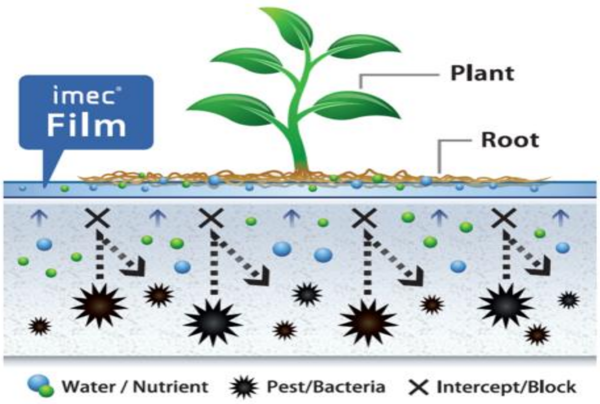
i. Waterproof sheet: that is spread on the ground to prevent contamination
ii. Non-woven fabric: placed above the water proof sheet, to absorb the nutrient medium
iii. Hydro membrane: is placed above the non-woven fabric where the plants grow
iv. Drip irrigation tubes: there are two drip tubes positioned, one situated below the non-woven fabric and the other placed above the hydro membrane which supplies the nutrient medium to crops.

The nutrient solution is delivered through the drip irrigation tube from top and bottom of the hydrogel film, while nutrient solution from the bottom causes a water stress that encourages the emergence of fine roots that sticks to the film's surface to absorb water efficiently. The hydro membrane receives water from the top to support the normal growth of plants. This system is highly efficient and requires fewer resources.

Production of high-quality crops

Water stress created in this system help to improve nutritional quality of crops. The hydrogel has limited ability to provide moisture to the plant when it absorbs water, and its surface remains dry. Therefore, to obtain the necessary moisture, the plant increases its sugar and amino acid content, which attracts water through osmotic pressure. This causes water to move from lower concentration of solutes towards areas with a high concentration of solutes. This increases the nutrient content in plants.

Tomatoes cultivated through IMEC system



Mechanism of hydrogel film blocks viruses and microorganisms.

Disease Free Crops

The hydrogel film, (hydro membrane), is made up of minuscule pores that are on a nano scale. These pores allow for the passage of nutrients while simultaneously preventing the entry of viruses and other harmful microorganisms, which helps to maintain disease-free crops. Additionally, because the roots attach to the surface of the film, they can be more easily examined and diagnosed. Hydrogel membrane permits water & other nutrients and blocks viruses and other microorganisms.

Sustainability and future aspects of IMEC system

Considering the impact of climate changes, rising population, and the availability of resources, the IMEC system offers a significant advantage to the agriculture sector. It enables the production of high-quality crops with increased productivity, utilizing fewer resources. The system optimizes the use of nutrient solutions, resulting in a 90% reduction in nutrient solution waste. Additionally, this system can be implemented in any location, including deserts, arid, and barren lands.

The IMEC system has been successfully implemented in Japan, where tomatoes grown using this method have gained popularity among consumers. This system has the potential to transform barren lands and other unused areas where traditional agriculture is not feasible into productive agricultural areas. Furthermore, the IMEC system has been tested successfully in the Dubai deserts. Based on data from 2013, it was reported that the IMEC system had applied for patents in 127 countries and was registered in 40 countries. According to recent reports given by India today several countries, including Singapore, China, Dubai, and Europe, have adopted film farming technology for cultivating fruits and vegetables. Mebiol, holds patents for this technology in 116 countries across the world. Therefore, owing to its notable achievements, film farming technology is currently being implemented in other countries, and there are future plans for expanding its usage even further.

Considering the emerging water crisis both globally and in India, innovative technologies such as hydro membrane will play a crucial role in the coming years. It is projected that by 2030, 40% of the Indian population may lack access to water, making food production more challenging and impacting the livelihoods of many. According to surveys conducted by economic experts, India is projected to face severe water insecurity by 2050. In this context, the use of hydro-membrane in agriculture can help conserve water resources, improve crop productivity, and ensure food security for a growing population.

This system is boon to agricultural sector where water and land resources are limited to feed the rising population and to sustainably produce food for future generations. IMEC system is a great solution for addressing these challenges.

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RECLAMATION OF SALINE SOIL THROUGH APPLICATION OF NANOPARTICLES

Barikara Umesh, Vikram Simha H.V., J B Kambale and Sharan Bhoopal Reddy

Soil is one of the important parts of environment which provides a critical ecosystem benefit for life. However, due to the urbanization, the rapid growth of industrializations has created side effects towards the soil. In recent decades, fertile soil has been converted into saline & alkaline by the hazardous and toxic pollutants that produced from the anthropogenic sources such as disposal of chemical-fertilizers wastes from industrial, abandoned use of fertilizers and pesticides, and other potential chemical sources which lead to the contamination of soil. For instance, 187 million tonnes of fertilizer and 4 million tonnes of pesticides have been used annually for agricultural crop in globally, which has led to the sources of soil salinization. There are several soil contaminants which include heavy metals, pesticides, mineral oil and solvents. Unscientific application of fertilizers in recent agricultural production was found to be the dominant source of soil salinization under major irrigation command areas in India. The attention towards the saline & alkaline soil problems has been raised with great concern as the contaminated soil will poses potential health impacts to the human, ecosystem, agricultural as well as the environment. Reclamation of these saline & alkaline soils gives huge opportunity to bring uncultivated lands in to agricultural & horticultural production. Many technologies like surface and subsurface drainage systems and use of gypsum as soil application were used reclamation of saline & alkaline soils. However, these technologies are high labour & initial investment and time consuming. Many agricultural scientists across the country used nanoparticles for reclamation of saline and other contaminated soils and reported positive results.

Nanotechnology and nanomaterials have been widely attracted the attentions from the industrial sector and was recently being used frequently in several fields such as agricultural, energy and environmental science. Small particle size of 1 to 100 nanometres was being used in the nanotechnology, with different types, high specific surface area, high reactivity and flexibility. With the vary properties of nanomaterials, they have the potential in removing the contaminants from soil, water and air. The high specific surface area of nanomaterials significantly increases the efficiency in decontamination process. The nanometres size of the nanoparticles enhanced their effectiveness in transported into the contaminated soil. The applications of nanotechnology techniques in remediation were investigated to have high efficiency, inexpensive, high flexibility and environmentally friendly.

Mechanisms of Nanotechnology

The application of in situ technique is widely used in soil remediation. The technologies used for remediation of saline soil is mainly adsorption, immobilization, Fenton and Fenton-like oxidation, reduction reaction and multiple combination of nanotechnology and bio remediation. The mechanism of combination of

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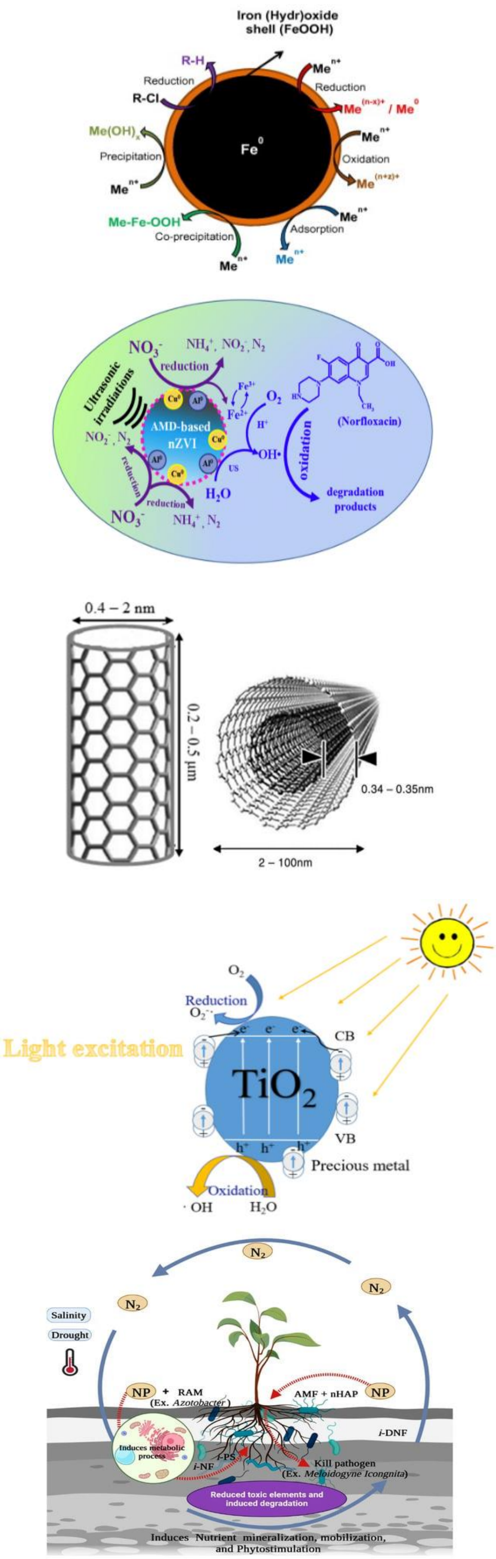
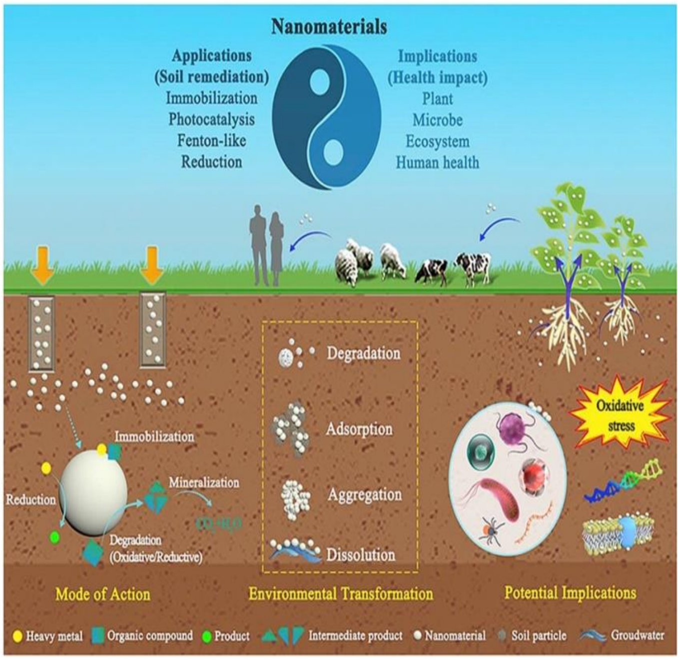


Different types of nanoparticles and their application in soil and water treatment

nanotechnology and bio remediation has arisen a great concern in recently. The inorganic contaminants such as heavy metals and metalloid were typically removed through the adsorption process by nanoparticles, while the organic contaminants were removed through reduction reaction and degradation with the presence of catalyses. With the implementation of nanomaterials, the process of adsorption and oxidation were able to degrade as well as remove the micro-pollutants that retained in soil environment. The applications of nanotechnology in soil remediation that are widely used in removing the contaminants include the carbon nanomaterials, Iron (III) oxide (Fe_3O_4), Titanium oxide (TiO_2), Zinc oxide (ZnO), nanoscale zero-valent iron (nZVI) and nano composites. Among the nanomaterials, nZVI was the most common used of nanoparticles in removing the heavy metal pollutants due to the high efficiency of nZVI in eliminating the contaminants such as toxic metals, chlorinated organic compounds and inorganic compound into less harmful compounds.

Pros and Cons of Nanotechnology

With the increasing of the application of nanotechnology in soil remediation, the number of nanomaterials will also be increased and entered the environment. The high number of nanomaterials may produce unpredicted risk towards the soil environment and ecosystem and indirectly threaten to human health. The main concern is the transportation of nanomaterials in the soil environment may transmitted into the groundwater system and pollute the water resources as well as the drinking water system and bring adverse impacts towards the terrestrial organisms and human health. The application of nanotechnology brings both benefits and disadvantages towards the ecosystem and environment. The presence of nanomaterials in the soil environment could enhance the growth of seeds and plants due to the enrichment of useful nutrients and pesticides. For instance, the various nanomaterials such as carbon nanotubes, metal and metal oxide nanomaterials has the ability to enhance the nutrient in soil by delivering the nutrient to the roots and leaves of the crops and thus improve the growth of crops. The application of metal oxide nanomaterials such as CuO has the potential to enhance the crops yield as well as the growth of crops due to the presence of virulent pathogens in CuO nano material. The disadvantage of the application of nano technology is the potential of toxicity towards the terrestrial organisms and soil ecosystem. It was found that there is potential toxic from nanomaterials towards the plant's cells. For instance, the concentration of carbon nano materials such as fullerene was found to be high in the plant's cells due to the process of translocation as well as uptake process. The translocation of the hydrophobic nanomaterials was due to the natural phenomena in the xylem, where the transport of nano materials was through the uptake of water and nutrients. Through the life cycle system, the uptakes of toxic by the plants will indirectly impacts towards the human through the ingestion of toxic crops. Besides that, the nanomaterials will also impact towards the properties of soils due to the small size of nanomaterials and high specific surface area. The nanomaterials could increase the porosity of soil and enhance the interaction between soil particles and organic matter.



Application of nanotechnology in saline soil reclamation

Challenges of Nanotechnology

The major challenges of nanotechnology are the negative effect of the nanoparticles towards the microbes. The toxicity in nanomaterials will affect the microorganisms and inhibit the enzymes activities in the soil environment. Several studies have been done to reduce and prevent the toxicity of nanomaterials towards the soil organisms. However, various conflict results have been reported as some studies presented the inhibitory ability and some studies investigated the bio stimulation impacts towards the microbial in soil system. In order to overcome the negative impacts that cause by the application of nanotechnology, further research and experiment are required to be investigated.

Conclusion

In summary, the application of technology for soil remediation includes the mechanism of reduction reaction and immobilization. Carbon nanomaterials, nZVI and metal oxide nanomaterials are the most efficient in removing or reducing the contaminants in the soils. The fate of contaminants in the soil environment is mainly linked to the pH value of the soil, the presence of clay mineral and content of organic matter. The application of nanotechnology has high efficiency in remediated the contaminated soils as well as enhance the useful nutrient to the plants and crops and increase the growth of yield. However, the nanomaterials could bring toxicity towards the plants cells and have negative impacts towards the soil environment as well as threaten human health. Thus, the application of nanotechnology in soil remediation is still require for further more investigation in order to promote the global environment.

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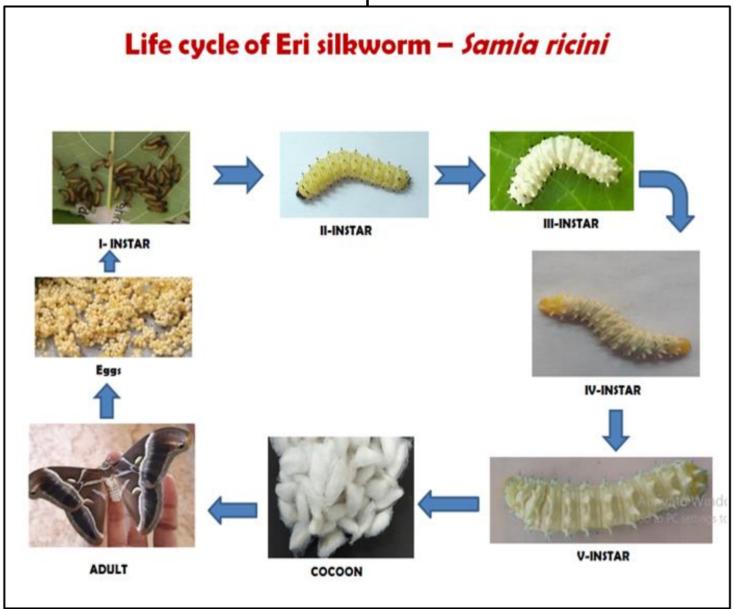
SCOPE OF ERICULTURE IN TAMIL NADU

R.K. Gokulakrishnaa and Selvamuthukumaran Thirunavukkarasu

Rearing of eri silkworm is called as ericulture. India is the only country which produces all the four types of silk i.e., Mulberry, Eri, Muga and Tasar, out of which eri silkworm is the only non – mulberry silkworm which is completely domesticated. Our country contributes more than 90 per cent (7,359 MT) of world's eri silk production (Figure 1 & 2) (CSB, 2022). Eri silkworm is polyphagous in nature and its host plants includes castor, kesseru and secondary host plants which include tapioca. Rearing of eri silkworm is traditional practice in North – east India particularly Assam, there eri pupae is also used as food as it is rich in protein and essential amino acids. Southern states of India particularly in Tamil Nadu ericulture gains popularity slowly among farmers as state sericulture department give subsidy as like for mulberry silkworm since 2019.



Biology of Eri Silkworm

Eri Silkworm, *Samia ricini* Donovan has five larval instars and moult four times. First three larval instars take each 2 – 3 days to grow, fourth larval instar take 4 – 5 days and fifth instar takes 5 – 7 days to develop. Between each instar it goes to moulting for the period 24 – 36 hours depending on the weather condition.

Special characters and advantages of eri over mulberry silkworm

When compare to mulberry silkworm, eri silkworm is resistant to diseases, hardy in nature and easy to handle and rear.

It constructs open ended cocoon; hence its silk is not reelable. Stifling process is not necessary as the adult emerge from the exit hole. Hence it is called as Ahimsa silk.

Short larval duration of 18 – 22 days where in case of mulberry it is about more than 25 days.

In Tamil Nadu, few districts like Salem, Dharmapuri and Erode are important tapioca cultivating areas. As tapioca is the secondary host of eri and it gives almost growth equivalent compared to castor in terms of economic parameters (Matured larval weight, Cocoon weight etc.,). So, the farmers may also rear by using the pruned leaves of tapioca (as it is traditional practice in the state at 6 months after planting a crop to enhance the tuber yield) and get some additional income.

Present status of ericulture in Tamil Nadu:

Tamil Nadu state government initiate the subsidy for rearing of eri silkworm on commercial basis from 2019 onwards for the scheduled caste and tribals only. From 2020 onwards, subsidy has been planned to give to all other communities. For scheduled caste and tribals it about Rs. 4500 for castor

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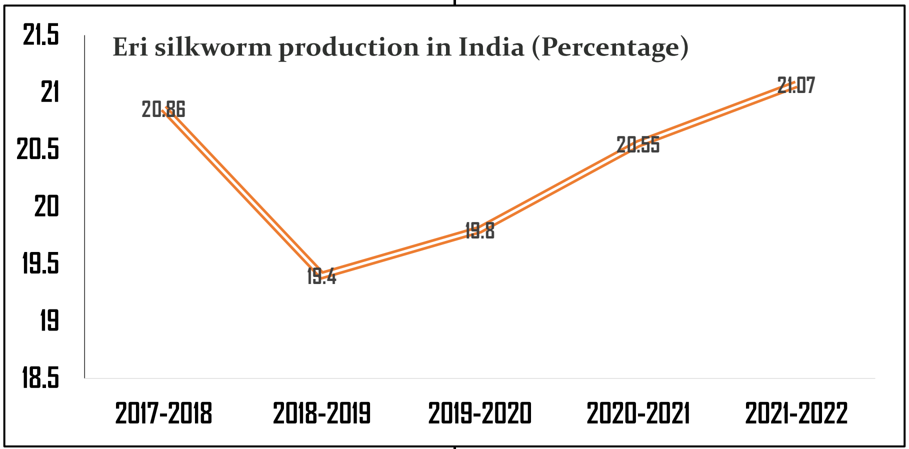
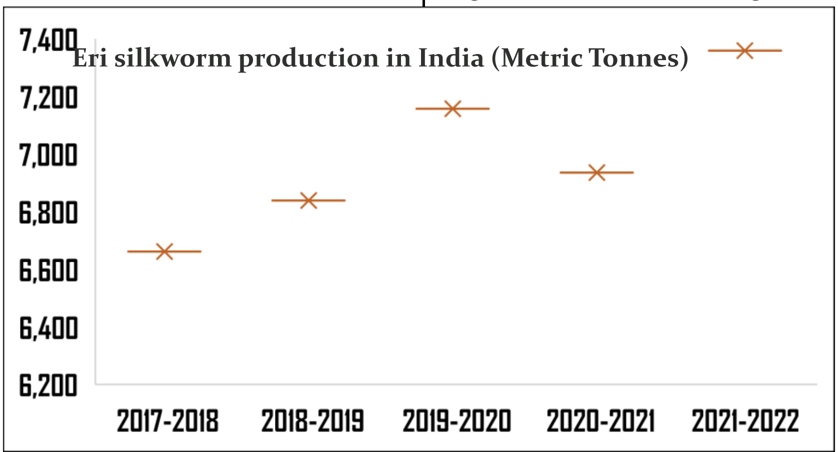
plantation/acre and Rs. 90,000 for the construction of the rearing shed, for other castes it is about Rs, 3700 for castor plantation/acre and Rs. 55,000 for the rearing shed (Primary data collected from technical officer, Thiruvannamalai district sericulture department, Tamil Nadu). At present, more than 250 farmers are ready to rear the eri silkworm as they raise the castor plantation of more than half acres.



Future scope of ericulture in entrepreneurship

In Tamil Nadu, total area under tapioca cultivation is 91.51 ha (Indiastat, 2020-2021). Fasae *et al.* (2009) reported the leaf yield of tapioca is 925 kg/ha. To rear 100 DFLs of eri silkworm around 1200 kg of leaves is required. From the reported leaf yield of Fasae *et al.* (2009) about 77 DFLs of eri silkworm can be reared and cocoon yield of around 70 kg can be obtained. 1 kg of eri seed cocoon is procured by Eri Silkworm Seed production center, Hosur at the minimum rate of Rs. 650. Hence, approximately around Rs. 52.000 can be earned through ericulture (100 DFLs) by tapioca growing farmers in Tamil Nadu.



Add-on benefit from eri silkworm

Eri silkworm pupae (Figure 3) has rich protein content (62.11%), lipids (26.21%) and moisture (8.55%). Apart from this it has higher linoleic acid, low Na/K ratio makes it an immense potential candidate as animal feed resources (Ray and Gangopadhyay, 2021), thereby eri silkworm pupae is anyway superior than mulberry silkworm pupae. Kongsup *et al.* (2022) studied the impact of *Samia ricini* pupae inclusion on growth performance, health, carcass, and meat quality of broiler chicken. They reported that broilers fed 10 percent eri silkworm pupae meal recorded highest cold carcass weight and skin yellowness than other feed groups, as well as it did not cause any negative consequences on all the parameters. However, they noticed the adverse effect when birds fed 15 percent eri silkworm pupae meal. Eri silkworm pupae is also utilized as a rich protein source, as potential to partial or complete replacement of fish meal and soybean meal.

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MANAGEMENT OF INSECT PESTS AND DISEASES IN GREENGRAM

Meenu, Sintu Malik, Gulab Singh and Mamta Phogat

Pulses are an important source of nutrition of people around the world. The food and Agriculture organisation of the United Nations has declared 2016 as the international year of pulses to promote the pulse area and to create awareness among people about their nutritional benefits. Pulses are a rich source of proteins, carbohydrates, fibres, vitamins and minerals. Globulins are the major storage proteins in pulse seeds constituting 35-72% of total protein and the remaining fraction mainly consists of albumins. Globulin proteins have higher amount of glutamine aspartic acid, arginine and lysine (Dahl et al., 2012). The insect pests reported on green gram includes jassid, *Empoasca motti* Pruthi; thrips, *Caliothrips indicus* Bagnall; whitefly, *Bemisia tabaci* (Genn.); semilooper, *Plusia orichalcea* (Fab.); cutworm, *Agrotis ipsilon* (Hufn.); galerucid beetle, *Madurasia obscurella* Jacoby; tortricid moth, *Cydia ptychora* Meyr; pod borer, *Maruca testulalis* Geyer; pod borer, *Helicoverpa armigera* (Hubner); stem fly, *Ophiomyia phaseoli* (Tryon.); green bug, *Nezara viridula*, (Linn.); (Kumar et. al., 2004; Nitharwal and Kumawat, 2013). Nitharwal and Kumawat (2013) observed that jassid, *E. motti*; whitefly, *B. tabaci* and thrips, *C. indicus* are the major insect pests of green gram, *Vigna radiata* in the semi-arid region of Rajasthan.

Management of major insect-pests of green gram

Hairy caterpillar- In young stage they skeletonize the leaves in gregarious form. They are of two types – Bihar hairy caterpillar and Red hairy caterpillar. Red hairy caterpillar infests the moong crops from second fortnight of July to August. Bihar hairy caterpillar attack from august to October. For management of these caterpillar's deep plough after harvesting of kharif crops so that pupae can be exposed to birds and other means and can be destroyed. They are attracted towards light so use light traps for one month after first rainfall. Destroy weeds because weeds are a major host for egg laying of these caterpillars. Destroy egg masses. Spray 250 ml Monocrotophos 36SL or 500 ml Quinalphos 25 EC in 250 litres of water per acre.

Jassid and whitefly- Spray 400 ml Melathion 50 EC or 250 ml Dimethoate 30 EC or 250 ml Oxydemeton methyl 25EC in 250 litres of water per acre. This will also help in management of yellow mosaic.

Management of diseases of green gram

Leaf spots- Angular brown spots which are dusky in centre and red-purple in margins are seen at leaves, stems and pods. Spray blitox-50 or indofil M-45@600-800 gm per acre in 200 litres of water.

Bacterial blight- On lower side of leaves small water filled spots are seen. Spray copper oxychloride @600-800 gm/acre in 200 litres of water.

Root rot- Diseased plants become yellow and shrinked. In severe infestation whole crop is destroyed. Treat the seed with 4 gm thiram per kg seed before sowing. Adopt crop rotation for at least 3 years.

Yellow mosaic- Diseased plants appear yellow and green. In severe infestation whole crop appear yellow. Yield loss is maximized in this condition. Grow resistant variety like MH-421, MH-1142. Whitefly is vector of this disease so manage whitefly population 20-25 days after sowing at 10-15 days interval with 250 ml dimethoate 30 EC or 250 ml oxydemeton methyl 25EC or 400 ml melathion 50EC in 250 litres of water per acre. Rogue out diseased plants. Keep field free from weeds.

Conclusions

Role of pulses in nutrition and maintaining soil fertility is in no doubt. But due to infestation of insect-pests and diseases yield losses are more. By

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timely management of pests and growing resistant varieties, integrated nutrient management these losses in green gram can be minimized to a great extent.

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ADOPTION OF CLIMATE-RESILIENT MAIZE HYBRIDS VS OPVS ON INCOME GENERATION

D. Thirusendura Selvi

Maize is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as the queen of cereals because it has the highest genetic yield potential among the others. In India, maize is the third most important food crop after rice and wheat. Maize in India contributes nearly 9 % of the national food basket, cultivated under 9.3 M hectares gross area. There were 15 million farmers engaged in Maize cultivation in India. Maize generates employment of more than 650 million person–days at farms. Maize qualifies as a potential crop in realizing the broader vision of doubling farmers' income by 2022. Maize is a source of more than 3,500 products including specialized Maize like QPM (Quality Protein Maize). Maize is the only food cereal crop that can be grown in different seasons and requires a moderate climate for growth since it has been recognized that C4 plant species have a higher optimal temperature for undertaking photosynthesis than C3 plants. Being a C4 plant, Maize uses 3-fold less water and gives a higher yield per hectare even in a shorter period than any other food grain crop. Improvement in the maize value chain across its various stages will be extremely crucial for making Indian maize competitive in the international market both in terms of quality and prices. Maize assumes significant importance in not only among food grains but also for the wholesome development of the agribusiness value chain in India (www. Ficci. in). Planting high-yielding single-cross hybrids played a major role in raising maize production. India stands at 5th rank in Maize hybridization in the world. Syngenta hybrids have made us market leaders in Karnataka, Andhra, Maharashtra, MP, Rajasthan and Tamil Nadu. Our focus is mostly in central and south India.

Maize consumption in India can broadly be divided into three categories viz. feed, food and Industrial non-food products (mainly starch). Feed accounts for about 60% of the maize consumption in India. The most important use and demand driver of maize is poultry feed which accounts for 47% of total maize consumption. Livestock feed accounts for 13%. Food consumption accounts for 20% of Maize consumption, with direct consumption being 13% and the form of processed food being 7%. Starch is the most important in this category accounting for 14% of the total maize consumption.

A combination of factors such as increasing industrialization, urbanization, housing activities and infrastructure development triggered the

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conversion of agricultural land into non-agricultural uses. This has resulted in a decline in the area under cultivation. The scope for expansion of the area available for cultivation is also very limited. The pattern of land ownership imposes limitations on the models that can be adopted for agricultural development. As per the latest Agricultural Census 2010-11, marginal and small holdings of less than 2 hectares accounted for 92.0 percent of the total holdings and 61.0 percent of the total operated area. They in turn are unsuitable for conventional technology and machinery use to boost agricultural production. This led to a process of marginalization of small and marginal farmers and the casualization of agricultural labourers.

A higher proportion of farmers rely on farm-saved seeds leading to a low seed replacement rate. It is desirable to achieve the required and recommended seed replacement rate to accomplish higher production and productivity. Quality seeds and planting materials are key agricultural inputs, which determine the productivity of crops. It is estimated that the quality of seed accounts for 20-25 percent of productivity.

Most of the remote farmers are smallholders, and their limited ability to purchase maize hybrid seeds is one of the reasons for the poor adoption of hybrid seeds. Dissemination of hybrid maize should target non-traditional areas also to scale the maize production at the local level. Due to changing climatic conditions, maize yield is adversely affected, so it is essential to concentrate on the promotion of climate-resilient maize hybrids. In that case, Drought-Tolerant Maize (DTM) hybrids are more profitable than open-pollinated varieties and offer resilience to changing climatic conditions. Moreover, maize hybrids provide higher yields compared with OPVs. However, there are several barriers to adopting maize hybrids by the small holding farmers, such as high prices and non-availability of the seed. As the price of maize hybrid seeds is high, smallholder farmers cannot afford to purchase them, forcing them to grow open-pollinated varieties. In this background, rapid adoption of drought-tolerant maize hybrid will be promoted among the small and marginal farmers of the targeted group. Further, a higher proportion of farmers are dependent on farm-saved seeds leading to a low seed replacement rate. It is necessary to achieve the required and recommended seed replacement rate to accomplish higher production and productivity. So, intervention in quality seeds and planting materials determines the productivity of crops.

Nowadays, seed quality enhancement approaches have been widely used to improve germination, reduce seedling emergence time and improve stand establishment and yield. It can enhance rates and percentage of germination and seedling emergence which ensure proper stand establishment under a wide range of environmental conditions. These post-harvest treatments include priming, hardening, pre-germination, pelleting, etc., improving their performance after harvesting and conditioning, but before they are sown. Therefore, hands-on practices and education on seed quality enhancement techniques and post-harvest handling are very much important at the farm level to upgrade their seed quality.

Improved maize cultivars have been observed to maintain maize cultivation, primarily under smallholder farming situations. The development of enhanced maize varieties remains a major goal of improved maize programmes and research organisations worldwide. If farmers use these upgraded OPVs, maize can deliver significant economic advantages through higher grain yields and lower risk. Smallholder farmers grow traditional maize types, which have lower production than modified maize varieties. The adoption of improved maize varieties is primarily owing to limited access and high prices, which result in decreased maize yield.

Many challenges, including economic, institutional, external, social, and cultural contexts, limit smallholder farmers' adoption of agricultural technology such as OPV maize varieties. Socioeconomic characteristics (such as age, education, gender, and family size) influence farmers' decisions to utilize improved maize seeds (OPVs). Technology also has a big impact on farmers' decisions to adopt OPVs. The adaption of improved hybrid seed production technologies with high-yielding hybrids enhances productivity with the available resources. There is scope for doubling the farm income through hybrid seed production by fetching more market prices than the grain cost of local varieties.

With the idea that farmers will use the improved maize variety, yields will increase, resulting in increased agricultural productivity and farm returns. Increased crop production and farm returns are the primary reasons for using improved maize varieties (OPVs). The adoption of enhanced maize varieties is a lifeline for the majority of the population in most parts of India that rely on agricultural production while living in drought-prone areas. This adoption boosts crop production and farm profits. It also helps maize growers and households reduce food insecurity and alleviate poverty at the home level.

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GM CROPS: UNLOCKING POTENTIAL AND NAVIGATING CHALLENGES

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Biotechnology has emerged as a game-changer in the agricultural sector, revolutionizing the way we produce food and manage crops. With advancements in genetic engineering and gene editing techniques, biotechnology has enabled scientists and farmers to develop genetically modified organisms (GMOs) with enhanced traits and manipulate the genetic makeup of plants. GMOs involve the introduction of specific genes from one organism into another to confer desired traits. In particular, the development of genetically modified organisms (GMOs) and gene editing techniques has opened new avenues for crop improvement. These innovations hold immense potential for increasing crop yields, improving resistance to pests and diseases, and mitigating the challenges of food security and sustainability. However, as with any ground-breaking technology, GMOs in agriculture is not without its share of controversies and ethical considerations.

Benefits and Ethical Considerations

In a world grappling with food security challenges, genetically modified (GM) crops have emerged as a promising solution, offering improved yields, resistance to pests and diseases, and enhanced nutritional content. Through the manipulation of genetic material, scientists have developed crops with desirable traits, revolutionizing the agricultural landscape. However, the adoption of GM crops is not without controversy, as concerns regarding safety, environmental impact, and socio-economic considerations persist. Genetically modified (GM) crops have garnered significant attention in recent years due to their potential to address pressing agricultural challenges. These crops are created through the alteration or introduction of specific genes to confer desirable traits, such as resistance to pests, diseases, or environmental stresses. While the adoption of GM crops has shown promise in enhancing productivity and sustainability, their benefits and ethical considerations require careful examination. One of the primary advantages of GM crops lies in their ability to increase agricultural productivity. By incorporating genes that provide resistance to pests and diseases, GM crops can reduce yield losses and decrease the reliance on chemical pesticides. This not only improves farmers' economic outcomes but also leads to reduced environmental impact, as fewer chemical inputs are required.

GM crops can also address nutritional deficiencies in certain regions. For instance, Golden Rice, a genetically modified variety, has been engineered to produce higher levels of beta-carotene, a precursor of vitamin A. Vitamin A deficiency is a significant public health issue in many developing countries, and Golden Rice offers a potential solution to combat this problem. Similarly, biofortified GM crops can be developed to increase the levels of essential micronutrients, addressing malnutrition on a larger scale.

Furthermore, GM crops have the potential to enhance sustainability in agriculture. Through genetic modification, crops can be engineered to withstand environmental stresses, such as drought, salinity, or extreme temperatures. This can help farmers adapt to changing climatic conditions and reduce the use of water and other limited resources. However, the adoption of GM crops raises ethical considerations that must be carefully addressed. One primary concern is the potential environmental impact of GM crops. While GM crops have demonstrated positive environmental outcomes, concerns about unintended consequences persist. Cross-pollination between GM

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and non-GM crops, for instance, raises worries about the potential spread of transgenes to wild relatives, impacting biodiversity. One concern is the impact on biodiversity, as gene flow from GMOs to wild relatives could potentially alter ecosystems. Critics argue that GMOs could lead to the loss of genetic diversity and the creation of "superweeds" or "superbugs" resistant to the engineered traits.

Furthermore, there are concerns regarding the long-term health effects of consuming genetically modified foods. While extensive studies have shown no evidence of harm to human health, the precautionary principle and the need for thorough safety assessments are emphasized by opponents. However, effective coexistence measures, such as buffer zones and isolation distances, can mitigate these concerns. Critics argue that GM crops could exacerbate socio-economic disparities, particularly in developing countries. Intellectual property rights and access to genetically modified seeds have been areas of contention. Patents and ownership of GM crop technology can raise issues of access and equity, particularly for small-scale farmers in developing countries. Ensuring fair distribution of benefits and promoting farmers' rights are essential to address these ethical considerations.

Transparency and informed consent are crucial elements when it comes to GM crops. Consumer preferences for GM products may vary, and the availability of clear labelling enables individuals to make informed choices about the food they consume. Public awareness campaigns and open dialogue about the benefits, risks, and regulations surrounding GM crops can foster greater acceptance and understanding.

Regulatory Frameworks

Regulatory frameworks play a vital role in addressing the ethical dimensions of GM crops. Rigorous safety assessments and monitoring systems are necessary to evaluate the potential risks associated with each genetically modified crop. Collaborative efforts among scientists, policymakers, and stakeholders can help establish robust regulations that ensure the responsible development, deployment, and monitoring of GM crops. Countries worldwide have implemented regulatory frameworks to address the complexities surrounding GM crops. These frameworks vary in terms of approval processes, labelling requirements, and coexistence measures. Regulatory agencies, such as the United States Department of Agriculture (USDA) and the European Food Safety Authority (EFSA), play a vital role in evaluating the safety and environmental impact of GM crops before market approval.

India, as a significant agricultural nation, has established regulatory frameworks to address the development, cultivation, and commercialization of genetically modified (GM) crops. These frameworks aim to ensure the safety of GM crops, protect the environment, and assess their potential socio-economic impacts. The regulatory process in India is primarily overseen by three key regulatory bodies: the Ministry of Environment, Forest and Climate Change (MoEFCC), the Genetic Engineering Appraisal Committee (GEAC), and the Review Committee on Genetic Manipulation (RCGM).

The MoEFCC, under the Environment Protection Act of 1986, is responsible for overall policy formulation and the approval of GM crops. It assesses the potential environmental risks associated with GM crops and grants permissions for their field trials and commercial cultivation. The ministry also considers the concerns of various stakeholders, such as farmers, consumer organizations, and environmental groups. The GEAC, a subcommittee of the MoEFCC, is tasked with the appraisal of GM crop proposals. It evaluates the safety data submitted by developers, conducts rigorous risk assessments, and makes recommendations on the approval or rejection of GM crop trials and commercial releases. The GEAC comprises experts from diverse fields, including environmental sciences, biotechnology, and agriculture.

The RCGM, under the Department of Biotechnology, focuses on the technical evaluation of GM crops. It examines the scientific aspects of proposed experiments, ensuring compliance with biosafety guidelines. The RCGM provides guidance on research and development activities related to GM crops, including monitoring, evaluation, and compliance with regulatory requirements. In addition to these regulatory bodies, India has implemented labelling requirements for GM food products. The Food Safety and Standards Authority of India (FSSAI) mandates that all packaged food products containing GM ingredients must be labelled accordingly. This allows consumers to make informed choices and promotes transparency in the food industry.

Addressing Safety Concerns

The safety of GM crops has been extensively studied and regulated. Scientific bodies, including the World Health Organization (WHO) and the National Academy of Sciences (NAS), have concluded that GM crops currently on the market are safe for consumption. Rigorous assessments have been conducted to evaluate potential allergenicity, toxicity, and environmental impact. Regulatory frameworks for biotechnology vary worldwide, with some countries adopting strict regulations, while others have embraced more flexible approaches. The regulatory frameworks in India emphasize a precautionary approach, focusing on the potential risks associated with GM crops. Risk assessments include evaluations of environmental impact, human and animal health, and potential socio-economic consequences. Stakeholder engagement, public consultation, and access to information are encouraged throughout the regulatory process to ensure transparency and democratic decision-making. Striking a balance between innovation and ensuring safety, transparency, and public acceptance is crucial. The consensus among scientists is that the risks associated with GM crops are not inherently greater than those of conventionally bred crops.

Conclusions

In conclusion, GM crops offer a range of potential benefits, including increased productivity, enhanced nutrition, and improved sustainability in agriculture. However, ethical considerations regarding biodiversity, long-term health effects, and ecological impacts must be carefully addressed and regulated. Ongoing research, transparent communication, and stakeholder engagement are essential in harnessing the benefits of GM crops while mitigating risks. As the global population continues to grow, embracing innovation and exploring sustainable agricultural practices will be crucial to meet the demand for safe, nutritious, and abundant food for all. An open and informed dialogue among scientists, policymakers, farmers, and consumers is essential to navigate the complexities surrounding GM crops. The potential benefits of GMOs in agriculture are extensive. They can enhance crop productivity, reduce the use of chemical inputs, improve tolerance to environmental stresses such as drought or disease, and increase nutritional value. GMOs have the potential to address food shortages, improve livelihoods for farmers, and contribute to sustainable agriculture practices. By embracing responsible innovation, rigorous risk assessment, and transparent communication, we can harness the potential of GM crops to shape a sustainable and resilient agricultural future.

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NATURAL FARMING FOR CLIMATE RESILIENCE AND SELF-RELIANT AGRICULTURE

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In conventional chemical-based farming practices, indiscriminate use of chemical fertilizers and pesticides adversely affects the beneficial soil micro-flora, leads to the changes in soil nature and also leads to high crop production cost. Heavy metals from the polluted soil may enter into the food chain in significant amounts and exhibit adverse health effects. It not only makes the soil barren but eventually, the farmer goes under debt (Bishnoi *et. al*. 2017). Hence, the only way out to deal with this ever-rising problem is Natural Farming. The essence of natural farming is to minimize the external inputs to the farm land, and nurture the in-situ soil fertility. In natural farming, the enrichment of soil occurs through propagation of beneficial soil microbes. It encourages the natural symbiosis process between soil micro-flora and crop plants. Mulching maximizes the moisture loss from the soil, forms the cover for the earthworms and minimizes the weed propagation.

Natural Farming is an art, practice and the science of working with nature to achieve much more with less. It builds on natural or ecological processes that exist in or around farms. It is a diversified farming system that integrates crops, trees and livestock, allowing the optimum use of functional biodiversity. Natural farming relies on traditional techniques and methods, which are designed to work in consonance with nature rather than against it. The goal of natural farming is to create a sustainable and self-reliant agricultural system that requires minimal external inputs (Khadse *et al.* 2018). Natural Farming is a method of farming, where the cost of cultivation is low. The farmer needs not to purchase fertilizers and pesticides in order to ensure the healthy growth of the crops. The method demands locally obtainable natural biodegradable materials supported with scientific knowledge of ecology and modern technology with traditional farming practices based on naturally occurring biological processes (Devarinti, 2016). This concept was coined by *Shri Subhash Palekar*, for which he was bestowed with *Padma Shri* in 2016. There are several formulations/products used as inputs in natural farming to fulfill the nutritional demand of the crop. It includes *Jeevamrit*, *Ghanjeevamrit, Vermicompost, etc.* assource of nutrients and microbial inoculum, and other formulations like *Neemastra, Brahmastra* and *Agnistra* as bio-control agents.

The history of natural farming can be traced back to Japan in the 1930s when a farmer named Masanobu Fukuoka developed a system of farming that relied on natural processes rather than chemical fertilizers and pesticides. Fukuoka's system, which he called "do-nothing farming", emphasized the use of cover crops, natural compost, and crop rotations to maintain soil fertility and control of pests and weeds.

Natural farming is based on several principles that guide its practices. These principles include:

No-tillage: Natural farming avoids plowing or tilling the soil, as this can disturb the soil structure and microbial communities. Instead, natural farmers use cover crops and mulches to suppress weeds and build soil fertility.

Natural composting: Natural farming relies on natural composting methods to build soil fertility. This involves using organic matter, such as cover crops, animal manure and kitchen waste to create a rich nutrient-dense soil.

Crop rotation: Natural farming uses crop rotation to maintain soil fertility and to control pests and diseases. Crop rotation involves planting different crops in the

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same field over several years to prevent the buildup of pests and diseases.

Intercropping: Natural farming uses intercropping, which involves planting different crops together in the same field. Intercropping can improve soil fertility and reduce the risk of pest and disease outbreaks.

Companion planting: Natural farming uses companion planting, which involves planting certain plants together to enhance their growth and repel pests. For example, planting marigold with tomato can help to repel nematodes.

Natural pest control: Natural farming avoids the use of chemical pesticides and instead relies on natural pest control methods. This includes using companion planting, crop rotation, and biological controls, such as predatory insects and birds.

Animal integration: Natural farming integrates animals into the agricultural system to improve soil fertility and pest control. This includes using animals such as chickens and goats to graze cover crops and provide natural fertilizer.

Table 1. Nutritional Composition in different formulations prepared at Gurukul, Kurukshetra

Formulation	N(%)	P(ppm)	K(ppm)	Zn (ppm)
Jeevamrit	0.896	2.976	884	1.38
Neemastra	0.672	2.193	1584	3.88
Agniastra	1.176	0.379	709	1.09
Dashparni Ark	2.184	0.339	602	1.83
KhattiLassi	2.80	25.835	430	2.24
Cow urine	1.50	6.788	9000	-

Source: *Report, IIFSR, Modipuram (2018)*

Methodology

The important principles of natural farming are intercropping, furrow method of cropping, contour and bunds system and using local species of earthworm. There are two types of formulations viz. *Jeevamrit* and *Ghanjeevmarit*, which help in the fulfillment of nutritional requirement of the crops, and the formulations which are used for insect-pest control are mainly *Neemastra, Brahmastra* and *Agniastra* (Table 2) (Palekar, 2014). The nutritional composition of different formulations as mentioned in table 1.

Benefits of Natural Farming

The benefits of natural farming can be seen in several different areas, including the environment, agriculture and society.

Environmental Impact

Natural farming can have a positive impact on the environment by reducing pollution, preserving biodiversity and promoting sustainable land use practices. By avoiding the use of chemical fertilizers and pesticides, natural farming reduces the amount of harmful chemicals that enter the soil and water, which can have negative impacts on wildlife and human health (Korav *et al*. 2020). Additionally, natural farming methods such as crop rotation and intercropping can promote biodiversity and reduce the risk of soil erosion.

Agricultural Impact

Natural farming can lead to healthier soils, crops and livestock, which can result in better yields and better product quality. By avoiding the use of synthetic fertilizers and pesticides, natural farming can improve soil health and fertility over time, which can lead to better crop yields. Additionally, natural farming methods such as companion planting and crop rotation can reduce the incidence of pests and diseases, which can improve crop quality. The result of natural farming has revealed that there is incredible enrichment of soils in terms of organic carbon (OC), available nitrogen, phosphorus, potash, micronutrients and biological health. The average organic carbon in the soil of the natural farming field ranges from 0.61 to 0.65% (IIFSR, Modipuram, 2017). The increase in the mean values of available nitrogen, phosphorus, potassium and micronutrients has also been reported. The available phosphorus, potassium, zinc, iron, copper and manganese were 89, 17, 32, 27, 31 and 117 percent, respectively higher under natural framing compared to conventional farming practices (Gurukul Farm Kurukshetra, 2017-2018).

Societal Impact

Natural farming can have positive impacts on rural communities by promoting self-sufficiency, reducing poverty and improving food security. By relying on natural resources and traditional knowledge, natural farming can help to build local capacity and promote community development. Additionally, natural farming can help to reduce the cost of inputs, making farming more affordable and accessible to small-scale farmers.

One of the main impacts of natural farming is that it can promote sustainable and self-sufficient agricultural systems. By relying on natural processes rather than external inputs, natural farming can reduce the environmental impact of agriculture and promote long-term sustainability. Additionally, natural farming can promote the use of local resources and traditional knowledge, which can help to build resilience and adaptability in the face of changing environmental conditions. By avoiding the use of synthetic fertilizers and pesticides, natural farming can produce crops that are free from harmful chemicals and have a higher nutrient content. It can promote biodiversity and the use of traditional crops, which can help to preserve cultural heritage and promote dietary diversity.

However, it is important to note that the results of natural farming can vary depending on local conditions, including climate, soil type and the availability of resources. Natural farming may not be suitable for all crops or farming systems and may require additional support or infrastructure to be successful. Therefore, it is important to carefully consider the local context and potential challenges before implementing natural farming practices

Disadvantage of Natural Farming

Natural farming also has some challenges. One of the main challenges is that natural farming requires more labor than conventional farming methods. It's because natural farming relies on manual labor rather than external inputs, farmers must spend more time in the field. Additionally, natural farming may have lower yields than conventional farming methods, which can make it difficult for farmers to compete in the global marketplace.

Another challenge of natural farming is that it requires a deep understanding of ecological processes and natural systems. Because natural farming relies on natural processes rather than external inputs, farmers must have a deep understanding of the soil, climate, and local ecology too.

Conclusions

Natural farming in terms of sustainability, saving of water use, improvement in soil health and farmland ecosystem, is considered as a cost- effective farming practices with scope for raising employment and rural development.

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Table 2. Formulations preparation and their benefits

S.No.	Ingredients	Preparation	Benefits
1.	*Jeevamarit*	It is composed of the desi cow-dung (10 kg), urine (8-10 l), jaggery (1.5-2 kg) and dicot flour (1.5-2 kg), water (180 l) and 500 g soil from under the tree. It is applied to the crops with each irrigation cycle or directly to the crops.	It provides nutrients, but most importantly acts as a catalytic agent that promotes the activity ofmicroorganisms in the soil, as well as increases earthworm activity. *Jeevamarit* also helps to prevent fungal and bacterial plant diseases. *Jeevamarit* is only needed for the first 3 years of the transition, after which the system becomes self-sustaining.
2.	*Ghan jeevamrit*	It is basically made up of water (20 l), cow dung (100 kg), Jaggery (1 kg), 2 kg of pulse flour (chickpea, pigeon pea, green gram and black gram), just a handful of soil and little bit urine.	It provides natural nutrients. Provides disease fighting fungus like *Trichoderma viride*. Promotes plant growth. Attracts local earthworms from 15 ft. soil depth.
3.	*Bijamrit*	Desi cow dung (5 kg), cow urine (5 l), lime or kali (250 g), water (20 l) and just handful of soil	*Bijamrita* is a seed treatment, equipped in protecting young roots from fungus as well as from soil- and seed-borne diseases.
4.	*Neemastra*	It is made up of local cow urine (5 l), cow dung (1 kg) and neem leaves and neem pulp (5 kg) and 100 l of water fermented for 24 h.	It is used for the control of sucking pests &Mealy Bug
5.	*Brahmastra*	It is prepared by 10 l of desi cow urine, neem leaves (3 kg), custard apple leaves (2 kg), lantern camellia leaves (2 kg), guava leaves (2 kg), pomegranate leaves (2 kg), papaya leaves (2 kg) and white *dhatura* leaves (2 kg), crushed and boiled in urine.	It is used to control all of the sucking pests, pod borer, fruit borer, etc.
6.	*Agniastra*	It is composed of 20 l local cow urine and 1 kg of tobacco, 500 g of green chili, 500 g local garlic. For spraying, 2-3 l. *Brahmastra*isis taken in 100 l water.	It is effective against the pests like Leafroller, Stem Borer, Fruit borer, Pod borer

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ROLE OF ROOTING MEDIA IN HORTICULTURE

Sushil Kumar and Vikash Hooda

Ornamental plants deliver a great diversity in terms of beautiful and aesthetic plants, cut flowers, foliage, bedding plants, indoor plants, potted plants, bulbous plants, outdoor plants, which depending on their growth habit may be annuals, biennials or perennials. Floriculture has become an important sector for entrepreneurs because of its ever-increasing demand and its potential to provide ample opportunities of employment.

Most of the horticulture and greenhouse plants are vegetative propagated and hence rooting media plays a vital role in the production of horticultural crops directly or indirectly.

Rooting Media?

Also known as "substrate", "potting media" and growing media is a soil-less medium in which plants are grown. The production of floricultural crops involves a number of cultural inputs. Among these, perhaps the most important factor which plays a major role in quality production and rooting of herbaceous cuttings of plants is rooting media. It is a substrate that helps to provide moisture, support, nutrients and aeration to the growing plant and helps in proper growth and development of plants.

Purpose of Growing Media

The rooting medium confirms the healthy plant production by providing it with a range of essential elements. Main purpose of rooting media are:

- providing support to the plant
- water absorption and retention
- provides nutrients directly to the root zone
- adequate gas exchange- aeration to the roots

Type of rooting media:

Peat:

Peat is obtained from remains of aquatic, marsh, bog, swamp vegetation found under water and formed when partially decomposed plants accumulate under water in areas with low temperatures and low oxygen and nutrient levels. The main property of peat is retaining moisture in soil when it's dry and preventing the excess of water from killing roots when it's wet.

Coco Peat

Cocopeat is a multipurpose growing medium made out of coconut husk. The fibrous coconut husk is pre washed, machine dried, sieved and made free from sand and other contaminations such as animal and plant residue. It has a very good aeration capacity.

Perlite

Perlite is an amorphous volcanic glass that has relatively high-water content, typically formed by the hydration of obsidian. It occurs naturally and has the unusual property of greatly expanding when heated sufficiently. It has property to improve aeration, drainage and reduce cost.

Vermiculite

Vermiculite is a hydrous phyllosilicate mineral. It undergoes significant expansion when heated. It promotes faster root growth and gives quick anchorage to young roots. The mixture helps to retain air, plant food, and moisture, releasing them as the plant requires them. It has high water holding capacity and sterile in nature.

Vermicompost

Vermicompost is stable, fine granular organic manure, which enriches soil quality by improving its physicochemical and biological properties. It is highly

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useful in raising seedlings and for crop production. It is produced by the fragmentation of organic wastes by earthworms. It is rich in micronutrients which are ideal for plant growth.

Shredded Bark/ Wood Bark

Small pieces of shredded bark can be used as constituent in growing and propagating media. This has the advantage of being biologically active and suppressing some diseases.

Rock-Wool

It is made from natural ingredients - basalt rock and chalk. Rock-wool for hydroponics is formed when heated at 1600°C, into lava. It is mainly used in displays of cut flowers. Other growing media constitutes pumice, charcoal, bagasse, leaf mould and sand.

Significance of Rooting Media

Growing media are used by the horticulture industry as well as consumers for the proper rooting in nursery and proper development of plants. Different growing media can be used to grow plants while the physical and chemical properties of media like structure, texture, pH as well as nitrogen, phosphorus and potassium are the dominant factors for the growth and development of plant. Growing media are used to grow a wide variety of plants including vegetables, fruits, floriculture ornamentals, tree and shrub ornamentals and plants.

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BUSINESS MEN TURNED TO - A PROGRESSIVE FISH FARMER

Akshaykumar, Sunilkumar N. M, Ningdalli Mallikarjun and Gynadev Bulla

Ornamental plants Diversification in farming is the need of the hour, in making decisions about diversification farmers need to consider whether income generated by new farm enterprises will be greater than the existing activities, with similar or less risk. While growing new crops or raising animals may be technically possible, along with the regular animal husbandry activity Inland fish farming gives an opportunity to establish themselves in better position for sustained income from farming sector.

Composite fish culture technology in brief involves the eradication of aquatic weeds and predatory fishes, liming: application of fertilizers on the basis of pond soil and water quality, stocking with 100 mm size fingerlings of Indian major carps-catla, rohu and mrigal, in regular supplementary feeding and harvesting of fish at a suitable time. The main aim of fish culture is to achieve the highest possible fish production from ponds and water resources. The techniques of fish cultivation involve both management of soil, water and husbandry of fish. Two criteria, less consumption of water by fish and high fecundity, go very much in favour of fish cultivation. Fish provide high quality food rich in protein, vitamins and other nutrients necessary for human health and growth. The scientific based technology of composite fish culture aims at maximum utilization of the pond's productivity. Fast growing, non-predatory, non-compatible species of food fishes are cultured together with complementary feeding habits and capable of utilizing both the natural and supplementary fish food. At the same time one fish is useful to the other.

Mr. Sharekhan Shemsharekhan, presently aged 40 years, was born and brought up at Janawada Village, of Bidar district has started the inland fish farming after undergoing the training at ICAR – Krishi Vigyan Kendra, Bidar. Initially Mr. Sharekhan Shemsharekhan interested in animal husbandry with regular technical advice and technical backup by Dr KVK Bidar Mr. Sharekhan started the construction of inland fish pond of size of 1 acre in his non usable agricultural land. During 2022-23 ICAR- KVK Bidar has demonstrated a composite fish farming under front line demonstration (FLD), KVK has been supplied with 6000 fish finger lings which includes Catla, Rohu and Common carp to the farmer from the Fisheries Research Information Center (FRIC), Bhutnal, Vijapura. Dr. Akshay Kumar, Scientist (Animal Science) in his supervision after releasing the fish fingerlings in the pond, every day farmer has fed

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them with fish feed and a mixture of wheat flour, rice bran and pulverized ground nut oilcake (GNOC) procured from market. He started harvesting fish after 10 months of release and has sold 3.5 tons of fish each weighing around 1.2 – 1.5 kg. Earlier he had invested Rs. 2 lakhs in production costs in addition to the construction of fish pond and total investment within one year with a satisfactory profit as well. This is accounting to a total business of Rs.3.85 lakh per annum. This could not have been possible without the support, service, technical help and motivation from the KVK Bidar & State Fisheries Department says Mr. Sharekhan.

By the initial support of KVK he is taking up Inland fish farming. He earns from sale of fishes. Now his farm has become visiting spot for the beginners of fish farmers and he has become farm youth icon to the surrounding villagers. The success of Khan does not stop here. He has inspired dozens of farmers towards fisheries activities to become fish farmers. It is now a model fish farm model fish farm.

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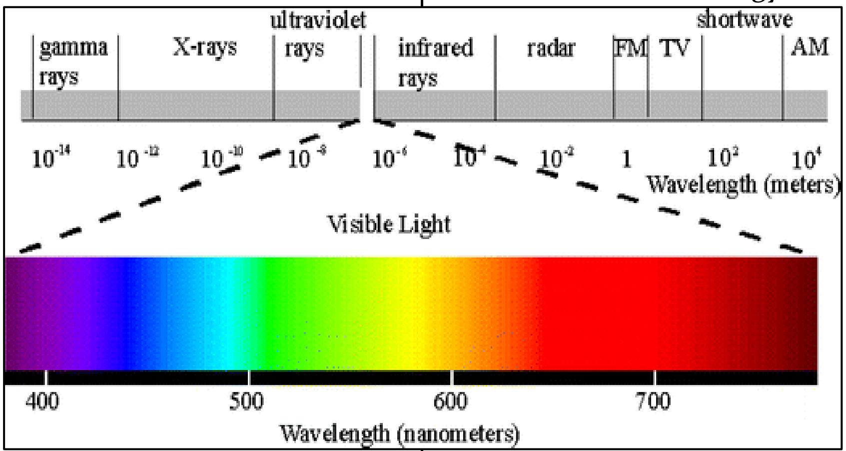
THERMAL IMAGING AND ITS APPLICATION IN IRRIGATION WATER MANAGEMENT

P. A. Pandya, S. H. Parmar, D. D. Vadalia and G.V. Prajapati

Process of capturing and creating an image of an object by using infrared radiation emitted from the object representing the temperature is called thermal imaging. Thermal imaging is the technique of using the heat given off by an object to produce an image of it or to locate it. All objects above the absolute zero temperature (0 K) emit infrared radiation as a function of their temperature. The infrared energy emitted by an object is known as its heat signature. In general, the hotter an object is, the more radiation it emits. The amount of radiation emitted by an object increases with temperature; therefore, thermography allows one to see variations in temperature. Thermal imaging is all about converting that infrared light into electric signals and creating an image using that information. A thermal imager (also known as a thermal camera) is essentially a heat sensor that is capable of detecting tiny differences in temperature. The device collects the infrared radiation from objects in the scene and creates an electronic image based on information about the temperature differences. Because objects are rarely precisely the same temperature as other objects around them, a thermal camera can detect them and they will appear as distinct in a thermal image. Works in environments without any ambient light and can penetrate obscurants such as smoke, fog and haze.



History

The underlying technology of the thermal imaging cameras was first developed for the military. However, the invention of the thermal camera is related to the history of thermography which began in 1960 by Sir William Herschel an astronaut who discovered infrared light. Both infrared radiation and visible light are part of the electromagnetic spectrum, but unlike the visible light, Infrared radiation cannot be perceived with human eyes directly.

Thermal Imaging Systems

Infrared thermal imaging system comprises of thermal camera equipped with infrared detectors, a signal processing unit and an image acquisition system, usually a computer. The infrared detectors absorb the infrared energy emitted by the object and convert it into an electrical impulse. The electrical impulse is sent to the signal processing unit which translates the information into thermal image. Most of the thermal imaging devices scan at a rate of 30 times per second and can sense temperature ranging from −20 to 1,500 °C, but the temperature range can still be increased by using filters (Meola & Carlomagno 2004). Detectors are the most important part of thermal imaging system which converts the radiant energy into electrical signals proportional to the amount of radiation falling on them. There are two types of detectors: thermal and photon detectors. In thermal detectors, infrared radiation heats up the detector element resulting in temperature rise, which is taken as a measure of the radiation falling on the object. In photon detectors, incident radiation interacts at an

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atomic or molecular level with the material of the detector to produce charge carriers that generate a voltage across the detector element or a change in its electrical resistance. The various types of photon detectors used are cadmium mercury telluride (CMT), indium antimonide, platinum silicide, and Quantum well devices. Among the two types, photon detectors provide greater sensitivity than thermal detectors (Willimas, 2009).

Thermal imaging devices can be classified into uncooled and cooled. Uncooled thermal imaging device is the most common one and the infrared detector elements are contained in a unit that operates at room temperature. They are less expensive but their resolution and image quality tend to be lower than the cooled device. In the cooled thermal imaging device, the sensor elements are contained in a unit which is maintained below 0 °C. They have a very high resolution and can detect temperature difference as low as 0.1 °C but they are expensive. Cooled thermal imaging devices are used in military and aerospace applications. An infrared imaging system is evaluated based on thermal sensitivity, scan speed, image resolution, and intensity resolution.

Thermal Imaging Cameras

A thermal imaging camera consists of five components: an optic system, detector, amplifier, signal processing, and display. The two most important factors are the detector resolution and the thermal sensitivity. The detector resolution describes the number of pixels. The most common resolutions are 160 x 120, 320 x 240 and 640 x 480 pixels. A 320 x 240 detector produces an image composed of 76,800 pixels. Since each pixel has a temperature associated with it that is 76,800 temperature data points. Higher resolutions also produce visibly clearer images. Thermal sensitivity is the smallest temperature difference the camera can detect. A sensitivity of 0.05° means the camera can distinguish between two surfaces with only a five-hundredths of a degree temperature difference. Another important factor to consider is the thermal imaging camera's temperature range. The range tells what the minimum and maximum temperatures are that the camera can measure (-4°F to 2200°F is typical). To obtain the best thermal image to analyse, there are four adjustments that can be made to most cameras: focus, emissivity setting changes, reflective temperature setting changes and thermal tuning.

Image Processing

Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame and the output may be either an image or a set of characteristics or parameters related to the image.

Applications

Agriculture, Medicine, Industries, Building Construction, Health care, Veterinary Thermal Imaging, Night vision and Targeting, UAV Surveillance, Food Processing, Surveillance in security, law enforcement and defence etc. In Agriculture, Thermal imaging has been successfully adopted for studying plant physiology, irrigation scheduling, and yield forecasting in agricultural fields. Likewise maturity evaluation, detection of bruises in fruits and vegetables, detection of spoilage in agricultural produces by microbial activities, and detection of foreign materials are the potential post-harvest operations to use thermal imaging.

Reviews on Crop Water Stress using Thermal Imaging

Canopy temperature and transpiration from leaves are closely related. Therefore, water deficit stress in plants could be effectively identified using temperature data from the canopy. Canopy temperature measurement using thermal infrared remote sensing is mostly used to study plant water relation. The plant water relation is directly dependent on stomatal conductance. The reason behind this

relationship is that the leaf temperature is determined by the rate of transpiration from the leaf.

The transpiration is a continuous process. When leaf water is evaporated due to transpiration, a substantial amount of energy is required to convert each mole of liquid water to vapour and this energy is taken away from the leaf in evaporating water, making the leaf cool (Jones *et al*. 2009). If there is water deficit in the ground, the plant closes its stomata to stop loss of water. These physiological changes determine the temperature of the plant. It means that low leaf temperature is due to open stomata in leaf whereas high leaf temperature will be an outcome of closed stomata. Crop water content is quantified using direct sensing of plant water stress parameters like leaf water potential, stem water potential (Matese *et al*. 2018) and relative water content (Krishna *et al*. 2019) etc. Soil-based experiments for water stress detection were reported as erroneous and were not found to be the representative. Mostly, crops are irrigated by applying water to the whole field uniformly. Lack of uniformity among plants, enhance the chances of reduced yield.

Table 1: Various studies on Applications of thermal imaging in 'Irrigation Water Management

Sela *et al.*, (2007)	Thermal imaging for estimating and mapping crop water stress in cotton	This study developed models for estimating and mapping leaf water potential (LWP) in cotton fields using thermal and visible images of cotton canopies. The models were based on the crop water stress index (CWSI) calculated from canopy temperatures and showed good correlation with measured LWP. The LWP-CWSI model was used to generate LWP maps of plots with different water status. These findings suggest the potential for using precision irrigation to promote water-saving in cotton fields.
Gontia and Tiwari, (2008)	Development of crop water stress index of wheat crop for scheduling irrigation using infrared thermometry	This study developed a relationship between canopy-air temperature difference and vapor pressure deficit for non-stress conditions of winter wheat crops to calculate the crop water stress index (CWSI) for irrigation scheduling. Linear relationships were found between canopy-air temperature difference and VPD, and the CWSI was calculated for three irrigation schedules. The established CWSI values can be used to monitor plant water status and plan irrigation scheduling for wheat crops.

Vadivambal and Jayas (2011)	Applications of Thermal Imaging in Agriculture and Food Industry—A Review	Infrared thermal imaging is a non-invasive, non-contact, and non-destructive technique with wide applications in various fields such as agriculture and food industry. The technique can assist in predicting water stress in crops, planning irrigation scheduling, disease and pathogen detection in plants, predicting fruit yield, evaluating the maturing of fruits, bruise detection in fruits and vegetables, detection of foreign bodies in food material, and temperature distribution during cooking. The review emphasizes the potential use of thermal imaging in various agricultural practices due to its advantages.
Gonzalez *et al.*, (2013)	Using high resolution UAV thermal imagery to assess the variability in the water status of five fruit tree species within a commercial orchard	The paper presents a viable method for precision irrigation management in commercial orchards by assessing water stress using remote sensing-derived indicators. The approach allows for the identification of water-stressed areas and variability within irrigation units. The Crop Water Stress Index (CWSI) was calculated and threshold values were defined for precision irrigation management based on crop developmental stages and economic considerations. This method provides an effective tool for growers to manage irrigation and optimize water use in orchards.
Masseroni *et al.,* (2017)	Assessing the Reliability of Thermal and Optical Imaging Techniques for Detecting Crop Water Status under Different Nitrogen Levels	The study confirms that imaging indices derived from thermal and optical techniques can be used as reliable operational tools to detect crop water status, regardless of the presence of nitrogen stress, making them potential tools for efficient irrigation management and detection of drought stress in different soil nitrogen conditions.
Kullberg *et al.*, (2017)	Evaluation of thermal remote sensing indices to estimate crop evapotranspiration coefficients	This study found that remote sensing methods, specifically the thermal indices DANS and DACT, were effective in estimating crop water stress and evapotranspiration in a deficit irrigation experiment for corn. These less data-intensive methods were found to have low RMSE in ET calculations, highlighting their suitability for estimating crop water stress. The study also provided insights into the appropriate remote sensing methods based on data availability and irrigation levels, along with an estimation of associated ET errors.

Bian *et al.*, (2019)	Simplified evaluation of cotton water stress using high resolution unmanned aerial vehicle thermal imagery	The study aimed to simplify the calculation of the crop water stress index (CWSI) and improve its diagnostic accuracy for cotton under different irrigation treatments using thermal and multispectral images. A simplified CWSI (CWSIsi) was developed and found to have higher correlation with stomatal conductance, transpiration rate, and soil volumetric water content compared to other methods. CWSIsi only requires parameters from a canopy temperature histogram and has potential for precision irrigation management.
Pereira *et al.*, (2020)	Prediction of crop coefficients from fraction of ground cover and height.	Study reported that crop water stress coefficient Ks can be calculated based on the temperature-based crop water stress index (CWSI) extracted from UAV-based infrared thermal imagery.
Krishna *et al.*, (2021)	Application of thermal imaging and hyperspectral remotesensing for crop water deficit stress monitoring	This study identified drought-tolerant and drought-sensitive rice genotypes using thermal and visible imaging techniques, along with measurements of relative water content and canopy reflectance spectra. The Crop Water Stress Index (CWSI) was used to quantify water deficit stress, and 10 most optimal wavebands related to water deficit stress were identified from hyperspectral data. The study provides valuable input for the development of drought-tolerant rice genotypes in the future.
G. Shao *et al.*, (2023)	Prediction of maize crop coefficient from UAV multi-sensor remote sensing using machine learning methods	The study found that the multispectral and thermal-based VIs, along with texture information from the near-infrared band, made significant contributions to the Kc-RFR model, particularly under different irrigation treatments. Additionally, the maize Kc-RFR model accurately estimated cumulative evapotranspiration ($R2 = 0.89$, RMSE = 15.0 mm/stage) during different growth stages and daily soil water content ($R2 = 0.85$, RMSE = 0.0089 m^3/m^3) in the root zone.
H. M. Jalajamony *et al.*, (2023)	Drone Aided Thermal Mapping for Selective Irrigation of Localized Dry Spots	A smart irrigation system is presented, utilizing a quadcopter drone equipped with a Thermal Infrared (TIR) camera and GPS module. The drone captures georeferenced thermal images to identify localized dry spots in an agricultural field. The images, along with flight data, are processed by an onboard edge intelligence module. Smart sprinklers in the field receive the coordinates of dry spots wirelessly and irrigate them selectively. A terrestrial edge unit utilizes a pre-trained machine learning (ML) model to generate an irrigation pattern by adjusting the head rotation angle (θ) and water flow control valve rotation angle (∅) of the smart sprinkler.

Conclusions

The application of thermal imaging is gaining popularity in agriculture and food industry in recent years. The major advantages of thermal imaging are non-contact, non-invasive, and rapid technique which could be used for online applications. The thermal cameras are easy to handle and highly accurate temperature measurements are possible. With the thermal imaging, it is possible to obtain temperature mapping of any particular region of interest with fast response times which is not possible with thermocouples or other temperature sensors which can only measure spot data. Repeatability of temperature measurements is high in thermal imaging. Also, thermal imaging does not require an illumination source unlike other imaging systems. Previous models of thermal camera's required cryogenically cooled sensors to obtain temperature resolution of 0.1 °C whereas recent day cameras can operate at room temperature making these cameras user friendly and promoting an increase in the use of thermal imaging in various fields.

The use of thermal imaging for irrigation and water management in agriculture is becoming increasingly popular due to its numerous advantages. Thermal imaging allows for non-invasive and non-contact measurement of temperature distribution, which can be used to predict water stress in crops and plan irrigation scheduling more accurately. This technology can also be used for disease and pathogen detection in plants and evaluating fruit maturation, among other applications. One approach to using thermal imaging for water management is through precision agriculture, which involves the use of agronomic concepts and innovative technology to control the geographical and temporal variance related to every aspect of agricultural output. Remote sensing technologies, including thermal imaging, can be used to monitor crop water status and attributes over vast distances, making data collection more efficient. Thermal imaging can be used to calculate evapotranspiration, which is the process by which water is transferred from land to the atmosphere through plant transpiration and soil evaporation. By accurately measuring evapotranspiration rates, farmers can more effectively plan irrigation schedules and conserve water resources. Infrared thermography is another technique used in thermal imaging for water management, which allows for the detection of temperature differences in crops and soil. By identifying areas of high and low temperature, farmers can identify areas of the field that require more or less water and adjust their irrigation accordingly. Overall, thermal imaging is a valuable tool for irrigation and water management in agriculture, allowing for more efficient use of water resources and improved crop yields. With advancements in technology, including the development of user-friendly thermal cameras, the use of thermal imaging in agriculture is likely to become more widespread in the future.

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IMPORTANT DISEASES OF PIG AND THEIR MANAGEMENT

Ranjan Kumar, Bhusan Kumar, Dhiru Kumar Tiwari and S.K Gangwar

Now a days there are no tradition of grazing in pigs farming. It might be due to non-availability of green fodder, hence there is a possibility of deficiency of mineral salt and vitamins in them leads to reduced growth of pigs and animals farmers get less profit. Therefore, it is necessary to know their information, symptoms and treatment. Following information is being given about some important diseases.

(A) Swine Fever/Swine Typhoid

It is highly contagious viral diseases of pig which spread very rapidly. The young ones/ piglets are more susceptible to the disease than older. The causative agents enter in the animals through gastrointestinal tract or contaminated feeding or watering, afterwards spreads in whole body through blood circulation.

Symptoms

Anorexia, Dullness, high fever (40.5-41.5 oC) or weakness, lameness, closing of eyelids. Initially constipation and later leads to diarrhoea and formation of special deformity on the Skin and discolouration of skin colour.

Transmission

- By means of contaminated feeding, watering, nasal/ mouth discharge/ faecal materials.
- Entry of newly purchased animals from outside.
- By contact suffering animals or by means of carriers through personal contact.

Control

Vaccination and regularly cleaning of farm shed and around.

(B) Diamond Skin Disease/ Erysipelasis

This disease caused by bacteria i.e., Erysipelothrix sps. which can survive many months/years as inactive state on normal temperature. It is characterised by diamond shaped skin lesion, diffuse erythematic skin, septicaemia and arthritis.

Symptoms

The joints of the body get swollen and the animals becomes lame. The animals do not able to walk. Small pink or pale-yellow spots are visible all over its body. That is why, called diamond skin disease.

Transmission

A diseased animal continuously excretes bacteria in their excreta and urine, which enter in healthy animals through contaminated feed and water. The bacteria survive and multiply for many years in moist soil. In India it is mostly occurs in the months of June-September.

Control

Isolation of diseased animals from the healthy group and offered them balanced ration. Treatment with penicillin and anti-Erysipelagic serum.

By Vaccination (should be done in the months of April and May).

(C) Swine shitla/Swine Pox

Swine flu/swine-pox disease is caused by virus.

Transmission

Spread by contaminated air, feed, water. It is also spread by Heamatopines suis (pig louse).

Symptoms

The animals suffering from mild fever. After one- or two-day, small pimples appears on the lower part of the body, upper part of the leg, on the face and back of the back and after 1-2 days they become bigger, in which pus is filled in 3-4 days and soon it become crust.

Control

- Isolation of diseased animals and providing light food to them.

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- Pig lice should be controlled; diseased pigs should be slaughtered.
- Cleaning of shed and around.

(D) Swine Vesicular Exanthema

It is caused by caused by a virus and usually appear in larger animals.

Symptoms

Appearance of blisters in the mouth and feed, sometime blisters appear on the gums, tongue, lips. This happens by eating's garbage.

Control

Special attention should be paid to the cleanliness of pig pens.

(E) Swine Plague/Galaghotu

Swine plague caused by a bacterium, i.e Pasteurella multocida.

There are two types of symptoms:

- Pneumonic Pasteurellosis which spread Pneumonia in the longs.
- Septicemic Pasteurellosis which occurs mostly in piglets and is very dangerous.

Transmission

Spread by means of contaminated feed, water and grazing on contaminated field/pasture.

Symptoms

High fever, loss of appetite, staggering, shortness of breath, sore throat, bloating, diarrhoea.

Control

- Diseased animals should be kept separate.
- The pig house should be clean, dead animals should be burnt or buried in the ground and use of lime on the dead animal.
- H.S. oil adjuvant or H.S. broth vaccine should be vaccinated

(F) Foot and Mouth Disease (FMD)

It is caused by virus Apthous virus

Symptoms

High fiver, Blisters form around the mouth, tongue and between hooves. The animals do not take feed and feels very thirsty. He is unable to walk due to pain.

Control

- Diseased animals should be kept separately; full attention should be given to hygiene.
- Animals mouth should be washed two-three times with Potassium permanganate solution.
- Vaccination should be done on 3 -4 months of piglet.

(H) Infectious Abortion/Brucellosis Disease

It is caused by a bacteria, Brucella Swiss

Symptoms

- Infertility in pigs.
- Abortion (Undeveloped foetus),
- Joint disease
- Weakness
- Testicular inflation in male pigs etc.

Control

- Isolation of diseased animals and culled.
- Infected male Pig should not be used for breeding purpose.
- Dead born foetus should be buried under the ground after abortion.
- Pig brought from other farms should be kept separately and tested for brucellosis.
- Farms should be kept clean.

Piglet

(a) Piglet Anaemia (lack of blood)

It is caused by mainly due to lack of iron and also copper, cobalt and Vitamin B. This disease mostly occurred in those piglets, who are rearing on cemented (Packka floor) floor leading to deficiency of hemoglobin in the blood.

Symptoms

Reduced growth rate, Loss of appetite, weakness, shortness of breath and swelling of the head and soldiers and death is more likely in piglets who is fed milk.

Treatment

Injection of Imferon @ 1 ml at the age of piglet 3-4 days or 2 ml. Iron dextran injection at three days and three weeks of age should given.

Control

- Piglets should be reared on Kaccha floor (Soil floor).
- 0.5 Kg Ferrous sulphate + 0.5 Kg Copper sulphate + 100 g Honey + 0.5 Kg water. This mixture should be rubbed on the udder of the female.
- Ferrous sulphate should be given in feed.

(b) Parakeratosis/ Zinc Deficiency

The deficiency of zinc causes a disease known as parakeratosis.

Symptoms

The skin becomes thicker and rougher than normal. Hair falling started from affected part of skin. Sometimes the hair of the entire body falls out. There is a decrease in the body weight of pig. Symptoms of zinc deficiency skin disease are similar to the disease of scalps and manage.

Treatment

- Supplementation of zinc to the pig's diet.
- Mineral mixture should be given in sufficient quantity (@ 30 g/day/Pig) in their ration.

(c) Iodine deficiency.

Iodine is very necessary for proper growth and development of the body. Iodine plays an important role in conducting many psychological functions.

Symptoms

The deficiency of iodine, a disease called Goiter. The disease also prominently found in animals, when there is presence of nitrate or thiocyanate and glucosinolate in the pig diet, which also leads to deficiency of iodine in the body. Loss of hairs in new born piglets.

Treatment

- Application of Iodine injection
- Supplementation of Iodized salt in the feed
- Uses of Mineral mixture @ 3 kg/ Qt. of feed

(d) Vitamin A Deficiency

Vitamin A deficiency is added due to deficiency in its quantity in the feed or due to improper absorption of feed's vitamin from intestine.

Symptoms

- The deficiency of vitamin A leads to improper development of brain in young ones and Night blindness in adult.
- The skin becomes rough. The iris of the eyes becomes white.
- Loss of body weight.
- Inability to produce child.
- Vitamin A deficiency should be rectified quickly, otherwise whatever symptoms appear, they become permanent.

Treatment

- Application of injection of Vitamin A (440 International units/Kg body weight).
- Addition of 0.3 microgram retinol or 5-8 microgram beta carotene per kg feed can be given daily in the diet to avoid vitamin A deficiency.

(e)Vitamin B deficiency

These are called water soluble vitamins. Vitamin B group compounds are synthesized in the pig's digestive system. Since the body growth rate of pigs is very high, they have deficiency of vitamins. In of this group the main vitamins are Thiamine, Riboflavin, Nicotinic acid, Pyrodoxine etc.

Symptoms

Beri-beri, Death of fetus in uterus, Weakness, Lameness, Dryness of Skin, Alopecia, Reduced growth rate, Loss of appetite, Constipation etc.

Treatment

Injection of Vit. B complex to piglets at 4 days and 15 days of birth. Since this vitamin cannot be stored in the body hence it should be offer per day.

(f) Hypoglycemia

Loss of blood sugar called hypoglycemia

Symptoms

- Weakness
- Shivering/tremor of animals
- Erection of body hairs

Treatment

- Injection/ saline of dextrose

  or

- Offering of glucose powder through drinking water

Control

- Regular feeding of mineral mixture (@ 3% in ration)
- Offering of green fodder as much as possible
- Animal should be kept in open pen with kachha floor
- There should be provision of sunlight in the farm

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SUMMER STRESS IN POULTRY: ITS EFFECT ON PRODUCTION AND MANAGEMENTAL PRACTICES TO AMELIORATE

Harshini Alapati, Jaishankar N and Shivakumar M. C.

Stress is any kind of deviation from the normal physiological homeostasis of the body. The term stress is used to describe the various factors that affect the health and performance of the birds. Animals or birds reacts to cope the stress conditions, by redistributing body resources including the dietary nutrients to withstand the stimuli at the cost of decreased growth, production and health. Long term exposure of birds to stress conditions leads to starvation and fatigue, furthermore increases susceptibility to pathogens, reduced immunity and results in death.

Stressors

Any stimulus that evokes the stress response is called "Stressor". These stressors can be broadly categorized into *viz.*,

Biotic i.e., virus, bacteria, fungi or parasites and

Abiotic factors such as temperature, solar radiation, humidity, overcrowding, poor ventilation, harsh handling, catching, immobilization, bright light, transport during hot hours, shortage of nutrients, toxins in feed, higher plane of nutrition for rapid growth etc.

Why Summer stress is a major concern???

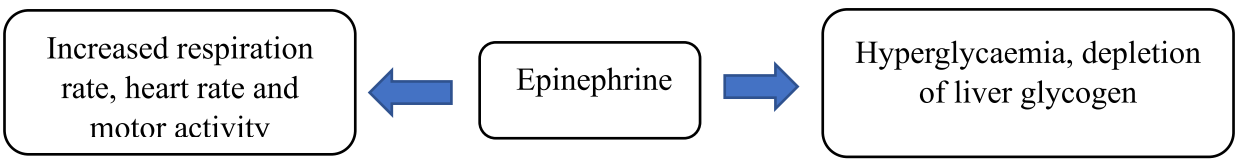
High ambient temperature in the tropics, like that of ours in India accompanied by higher relative humidity resulting Heat stress is one of the most inevitable stressors in poultry production.

- Birds are more susceptible to high environmental temperature than low environmental temperature due to absence of sweat glands, feathered body, fatty nature and high body temperature (40.1 to 41.6°C / 105 to 106.4°F).
- The degree of susceptibility to tropical heat stress is higher in broilers than layers attributed to their rapid growth and higher metabolism.
- Among broilers males are more susceptible to heat stress than females with respect to their body size.
- Good layers (commercial lines) housed in cages are more susceptible than poor layers (developed varieties of native chicken ex: Swarnadhara, Vanaraja) reared on deep litter system of housing.
- Most of the commercial layer and broiler houses in the Indian scenario are open sided, i.e., only 1 to 1.5 feet of side wall is constructed with, rest is made of wire mesh. Exposure to direct hot drafts of wind is inevitable during peak summer months.

What happens to birds during heat stress!!!!!

Physiological mechanism of the body in response to the heat stress is similar any type of the bird, exception to duration and intensity of stressor. When the intensity of stress exceeds threshold level, birds exhibit stress syndrome, which is manifested in three stages

1) Stage of alarm or neurogenic reaction – it is the initial response of the body mediated by sympathoadrenal axis immediately after the identification of stressful stimuli. This reaction operates for short term regulation of stress or disturbance by the nervous



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system and stimulates the sympathetic post ganglionic fibres to release the epinephrine from adrenal medulla.

2) stage of adaption or resistance (endocrine) – if the stimulus persists for the longer duration, endocrine system reacts through activation of Hypothalamic-pituitary-adrenal axis (HPA).

Hypothalamus

↓ *Corticotrophin releasing hormone*

Pituitary gland

↓ *Adrenocorticotrophic hormone*

Adrenal cortex

↓

Corticosterone →

Delays proliferation of intestinal epithelial cells → Decreased villus height & crypt depth → damages intestinal mucosa → pro-inflammatory agents alter the tight junctions of intestinal epithelium → increases the permeability of pathogens

↓

- Breakdown of muscle and gluconeogenesis→ raises blood glucose.
- Electrolyte imbalances → increased blood volume & pressure.
- Panting → Respiratory alkalosis → reduced pH, HCo_3^{2-} -→ Impairs shell calcification.
- Reduced levels of FSH & LH → decreases Estradiol concentration→ impairs follicular size & yolk quality and fertility.
- Suppression of immune system.

3) stage of exhaustion – when the body couldn't restore the normal physiological process as the reserves falls deficit.

Indicators of Heat stress

- ➢ Increased body temperature
- ➢ Decreased voluntary feed intake (anorexia).
- ➢ A rise in the level of plasma corticosterone, insulin or glucagon.
- ➢ Decreased growth and increased muscle degradation.
- ➢ Release of acute-phase cytokines (monokines and lymphokines).
- ➢ Impaired growth of cartilage and bone.
- ➢ Synthesis of specific heat shock proteins.
- ➢ Increased heterophil: lymphocyte ratios (i.e., changes in the numbers of circulating leucocytes profiles).
- ➢ Atrophy of the thymus and bursa of fabrics in young birds → Immunosuppression
- ➢ Excessive fat deposition in the abdomen (abdominal fat pad).
- ➢ Ascites (water belly) in high producing broilers.

Table 1: Environmental Temperature and signs in the domestic poultry

55°F – 75°F	Thermoneutral zone
65°F – 75°F	Ideal temperature zone
75°F – 85°F	A slight reduction in feed consumption
85°F – 90°F	Feed consumption falls further, cooling should be started before this temp is reached.
90°F - 95°F	Feed consumption continues to drop, danger of heat prostration among layers, cooling strategies should be taken
95°F-100°F	Heat prostration, water consumption is high.
>100°F	Emergency measures must be taken, survival is concern at these temperatures.

How to ameliorate the heat stress???

Environmental strategies - Intermittent Photoschedule (light).

Housing management - Sites election, design and construction, ventilation, internal and roof cooling, Density of birds.

Nutritional strategies- Increasing energy density, Amino acid balance, Vitamins – A, C, E, minerals, non-nutrient feed additives, Water and electrolyte balance.

Feeding strategies - Early feeding, Intermittent feeding, Sex separate feeding, Fasting or feed with drawl, changing the physical form of feed.

Genetic strategies -Selection for heat tolerance, Selection for disease resistance, Use of major genes – Naked neck (*Na*), Frizzle(*F*), Dwarf(*dw*), Silky (*h*), Slow feathering (*K*).

Early heat conditioning or epigenetic programming.

1. Environment Strategies

Intermittent Photo Schedule

An intermittent light regime can improve the feed efficiency and thus the broiler production efficiency, by decreasing the fat deposition associated with increased incidence of leg abnormalities, metabolic and cardiovascular diseases, ascites. The favourable effect is related to the lower heat production during both light and dark period.

This photo schedule contains more than one scotophase and one dark phase which recur at 24 hr intervals. This regime increases the feed consumption during cooler part of the day.

Symmetric - when scotophase and dark phase are of equal length.

Asymmetric - when they are not in equal length.

- broiler raised under 2L:4D & 1L:3D intermittent light regime showed significant improvement in the tolerance level of heat stress.
- The initial reduction in body weight gain of birds under intermittent schedule is followed by compensatory growth, but the compensatory growth depends on genotype and sex.
- Physical activity in broilers were lowest under 100Hz fluorescent light and highest under incandescent.

2. Housing Management

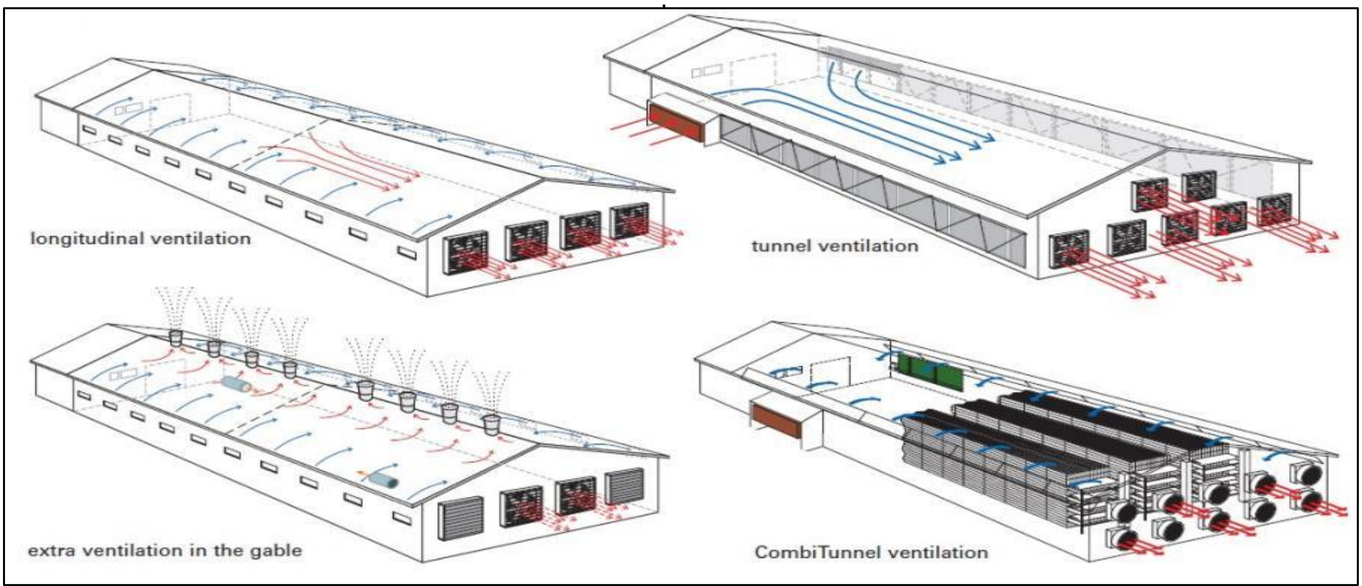
- Orientation: east west to reduce direct solar radiation
- Shade of trees and green crops around the houses will prevent direct heating, vegetation should be mowed frequently so that it does not obstruct air flow
- Houses should be oriented perpendicular to wind direction for maximum air movement.
- Recommended spacing between two sheds $D=0.4\times H\times L(0.5)$ [H & L height and length in feet.]
- Width of building should not exceed 12 meter.
- Gable roof is ideal for the tropical climates for effective ventilation (for removal of hot expired air).
- Insulating materials like sawdust and straw can be used to reduce influx of heat into the building.
- Good reflective roof coating on the exterior of the roof to reduce roof temperatures
- The outside walls and roof should be painted white or any reflecting paint i.e., metallic zinc or aluminium.
- Roof should be clean and dust free to improve the reflectivity of solar radiation.
- In open sided houses wet curtains or gunny bags may be hanged over the wire mesh.
- Drawing air through adsorbent, porous cooling pads and fan system, vertical ceiling fans at 3-7 m above the birds and 7.6-15m apart depending on size and air velocity.
- In house fogging, sprinkling over roof.
- Cross ventilation or tunnel ventilation system for effective exchange gases and expired air
- Full monitor type of roofing is the best for the tropical climates as it provides vertical ventilation.
- Reduction of housing density to 30% enhances the ventilation rate

Covering the side walls with curtains during the peak temperatures of the day

Foggers inside the shed.

Sprinklers on the outside of roof.

Types of Ventilation to improve wind flow in environmentally controlled houses



3. Nutritional Strategies

Increasing Energy Density

ME requirements of birds decreases with increasing temperature due to reduction in energy requirements, resulting in growth depression. Increasing the energy density can partially overcome the growth depression. Higher fat content reduces heat production since fat has lower heat increment than protein and carbohydrate.

Dietary Protein and Amino Acid Balance

- The protein requirement is decreased because of the suppression in production performance.
- It has been shown that both protein synthesis and breakdown are affected by chronic heat stress, and protein synthesis is more affected than breakdown, leading to reduced protein deposition.
- The decreased protein synthesis cannot be restored by high dietary protein level. Moreover, a high protein diet even leads to higher metabolic heat production resulting in depressed growth.
- Special balancing of arginine, leucine, Sulphur containing amino acids is essential.
- Lysine deficiency increases the body temperature.

Vitamins

- The detrimental effect of heat stress on egg production can also be alleviated by dietary supplementation of Vitamin A (8000 IU/kg diet). It improves the immune status of heat-stressed laying hens.
- Supplementation of cholecalciferol, Vitamin E, K .
- 200 mg vitamin C and 200 mg Vitamin E per kg of feed, improves the antioxidant defence of the

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heat stressed chickens against free radical damage .

Minerals

- Marginal phosphorus levels, when combined with heat stress, can lead to increased mortality rates, particularly among older birds.
- Dietary supplementation of chromium (120 ppb) is favourable during heat stress as it increases feed intake and body weight, improving feed efficiency and carcass characteristics.
- Zinc (4.5 mg/kg) supplementation resulted in an improved live weight gain, feed efficiency, and carcass quality traits

6. Non nutrient feed additives

Heat stress alters the diversity and abundance of gastrointestinal microbiota. Supplementation of probiotics in feed such as *Lactobacillus spp, Bifidobacterium spp* strains may enrich the diversity of flora in chicken jejunum and caecum, and therefore restoring the microbial balance and maintaining the natural stability of jejunal and caecal microbiota of broiler chicken exposed to heat stress.

Water and electrolytes

The suppression of growth in broilers can be partially alleviated by supplementation of 1% NH_4Cl or 0.5% $NaHCO_3$ and 1.5 to 2.0% K in the form of KCl. Supplementation of $NaHCO_3$ @ 4 -10 Kg per tonne in layers helps in the mineralization of shell and restores the defects of caused due to heat stress

Table 2: Water requirements of chicken

Type of bird	Season	Water: Feed intake
Growing	Summer	2- 2.5
Growing	Winter	1.5 – 2
Layer	Summer	2.6 – 3.5
Layer	Winter	1.8 – 2.2

4. Feeding Strategies

- Temporary feed restriction before heat exposure is an effective way to enhance thermal resistance of broilers.
- Feed withdrawal reduces heat production, increment speed of body temperature and mortality of broilers.
- The dual feeding programme is another strategy used for broilers, which includes a protein diet during the cooler phase and an energy-rich diet during the warmer phase of each day and maintains a nutritional balance by adequate proportion of the two diets.
- During heat challenge, dual feeding reduces the body temperature and mortality.
- Partial feed restriction of broilers during day 4 to 6 was experimentally proven to improve growth rate and thermal resistance to heat stress during marketing age (35-42d).
- Feeding schedule for laying hens should comprise $1/3^{rd}$ ration early in the morning and $2/3^{rd}$ after the peak temperatures or evening.
- Some experiments shown that night time feeding improved the egg shell quality of heat stressed laying hens.
- Wet feeding increases the dry matter (DM) intake and, therefore, alleviates partially the effect of heat stress on feed intake and laying performance. Feeding a wet diet containing 50% moisture increased the DM intake of layers at high temperature.
- Normally the layer diet is provided in mash form. During summer, although the feed consumption is not affected by pelleting the ration, egg production, feed efficiency and water intake were significantly increased in laying hens.

5. Genetic Strategies

In poultry, there are several traits that favour heat tolerance. Feather features can be controlled by selection and breeding plans with the use of dominant genes such as naked neck (Na) or frizzle (F) genes. Tropical relevant genes in local fowl

Naked neck gene: presence of this gene decreases the feather covering by 20% and 40% (relative to body weight) in the heterozygous (*Na*/*na*) &homozygous (*Na*/ *Na*) birds respectively. The beneficial effect of Na genotype is more pronounced in broiler chickens with high growth rate and breast meat yield Ex: HIT CARI developed by Central Avian Research Institute.

Frizzle gene: Frizzle (*F*) gene may reduce the heat insulation of feather by curling the feathers and reducing their size. Effect of heat tolerance is lesser than that of Naked neck gene. However, there is an additive effect in the heterozygous gene utilization (Na/na F/f) in broiler chickens Ex: Caribro Tropicana, Cari Bro Mrutyunjay

Selection For Heat Tolerance

- WLH shown to have greater tolerance than heavier breeds like RIR, barred PR, white PR and Austarlop.
- Use of temperature-controlled chambers for short periods (37^{0}C & 60% RH)
- Survivors were reproduced after recovery phase of 60 days, survivability rate improved from 16% to 69% in 7 generations.
- Superior egg production was noticed in thermotolerant birds.

7. Early Heat Conditioning / Epigenetic Programming

Epigenome is the protein covering that constitutes histone proteins around the DNA, epigenome regulates the expression of the genes and plays a crucial role in the early prenatal period in the determination of up or down regulation of gene expression related to environmental stressors. exploitation of epigenetics is useful for the development of thermotolerant strains of chicken.

Table 3: List of genes that affect the thermotolerance in chicken

Gene	Nature of inheritance	Direct effect	Side effect
Dwarf (*dw*)	Sex linked recessive multiple allelic	Reduction in body size up to 10 - 30%. Mostly utilized in broiler breeding.	Reduced metabolism improved fitness, disease tolerance.
Naked neck (*Na*)	Incomplete dominant	Loss of neck feathers, reduction in secondary feathers	Improved ability for convection and adult fitness
Frizzle (*F*)	Incomplete dominant	Curling of feathers	Improved ability for heat tolerance
Silky (*h*)	Recessive	Long barbs at the contour feathers	Improved ability for convection
Slow feathering (*K*)	Dominant sex linked multiple	Delay in feathering	Increased heat loss, reduced adult mortality

Early heat conditioning in broilers chicks by exposing to 36º C for 24 hours during 3 to 5 days of age, improved the heat tolerance and growth efficiency, reduced mortality rate in later stages of life (35d). compared to the control group. Increasing the temperature during embryonic growth i.e., E07 to E17 improved the thermotolerance, egg production and lowered plasma corticosterone levels in laying hens.

Conclusions

"Effective stress management involves complete elimination of avoidable stressors and minimizing the load of unavoidable stressors on the birds." Protection of bird's welfare, minimizing of production losses and mortality cannot be achieved by adapting one or two managemental practices. Cascade of housing & environmental strategies, balanced dietary nutrients, special feeding schedule during summer months and improvement of genetic potential of birds through selection and utilization of Naked neck and frizzle will benefit the poultry farmers.

* * * * * * *

“Farming Isn’t Something That Can Be Taught. Each Plant Tells Its Own Story That Has To Be Read Repeatedly”

-KELSEY TIMMERMAN