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CARBON DOTS: NEW CARBON-BASED NANOMATERIALS

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ABSTRACT

Nanomaterials are materials with dimensions between 1 and 100 nm, tiny in size, with at least one dimension ≤ 100 nm. A new category of fluorescent carbon nanomaterials replaces the traditional semi-quantum dots. Carbon dots (CDs) have been explored in the last few years for their simple synthetic accession, good bio-consonance and several revelation applications. The properties, such as distinct photoelectronic and fluorescent properties, chemical inertness, etc., make CDs well-positioned to achieve unprecedented performance. The characteristics features like high photostability, biocompatibility, straightforward synthetic methods, flexible designability, etc., makes CDs the next generation of fluorescent probes.

INTRODUCTION

Since the beginning of the twenty-first century, nanotechnology has emerged as one of the most significant topics in various fields such as ecological preservation, electronics manufacture, astronomy, drug synthesis and delivery. Nanoparticles are currently used to produce countless everyday objects, including tyres, cosmetics, sunscreen, stain-resistant clothing and electrical equipment. Nanomaterials are microscopic particles with a minimum of one external dimension measuring 100 nanometers (one-millionth of a millimetre) or less (Nayak *et al.*, 2021). In comparison, human hair has a diameter of roughly 70,000 nanometers. The nanomaterials with one dimension, such as thin films and surface coatings, are known as "nanolayer".

Furthermore, the nanotubes and nanowires have two dimensions in the nanoscale. Nanoparticles are those which have all three dimensions in the nanoscale. Also, we can divide nanomaterials into carbon-based materials, metal-based materials, dendrimers, and composites. In the family of carbon-based nanomaterials, the carbon dots (CDs) defined by a feature size of <10 nm are a rising star with discrete quasi-spherical nanoparticles. Xu and coworkers accidentally discovered these carbon dots in 2004 for the first time (Xu *et al.*, 2004). These CDs have significant applications in a variety of fields, such as biomedicine, catalysis, optoelectronic devices, and anticounterfeiting, all thanks to their excellent and controllable photoluminescence (PL), high quantum yield (QY), low toxicity, small size, appreciable biocompatibility, and widely available low-cost sources (Liu *et al.*, 2020).

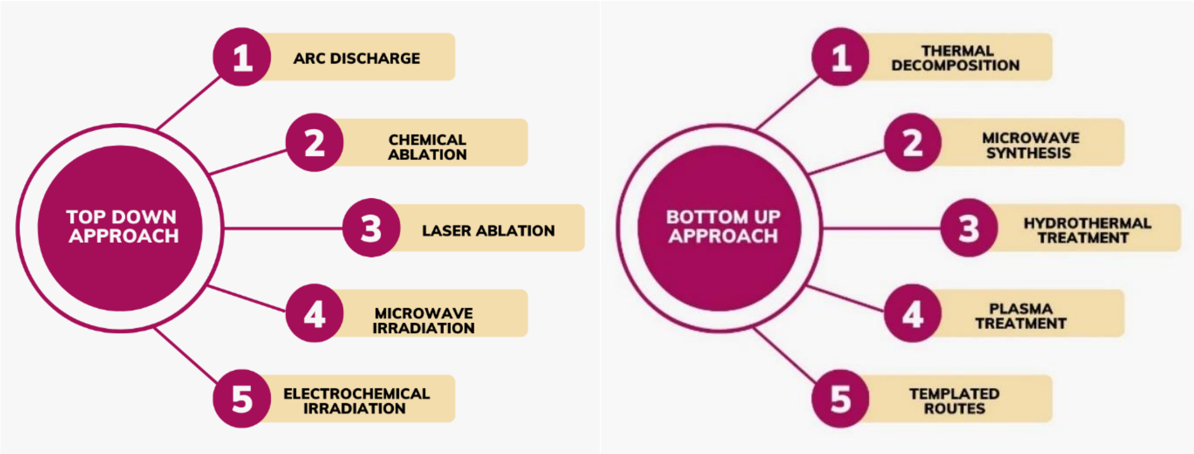

Fig.1 Different methods for synthesis of carbon dots

These carbon dots have recently found profound applications in the efficient detection of trace-level pesticides present in different parts of the environment. Broadly these CDs can be prepared by two approaches: "top-down" and "bottom-up". Ultimately, surface passivation and surface functionalization are used as surface modifications to enhance the surface characteristics of CDs (Fig. 2).

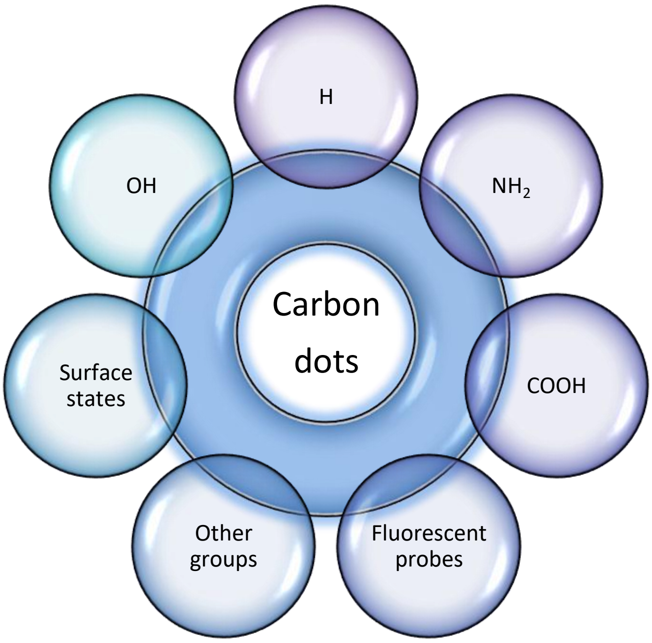

Fig. 2 Carbon dots with different surface functionalization

PHYSICOCHEMICAL PROPERTIES OF CARBON DOTS

1. *Absorption:* CDs show excellent optical absorption in the ultraviolet (UV) region (mainly 280-360 nm). The absorption may increase up to near-infrared region through surface modification.

2. *Fluorescence:* CDs show a type of photoluminescence because of their zero-dimensional structure. CDs exhibit strong fluorescence effects and are being developed as fluorescent molecules due to their excellent biocompatibility, low photobleaching, and protein surfaces, which are highly desirable for molecules to be used in biomedicine and biosensing.
3. *Phosphorescence:* When water-soluble CDs were employed as a phosphorescent material, the phosphorescence characteristics of CDs were brought to light.
4. *Chemiluminescence:* CDs have excellent chemiluminescence properties that have been exploited to determine different radioactive substances. C-dots concentration within a specific absorption range is the only factor influencing chemiluminescent intensity.
5. *Quantum yield (QY):* It is defined as the ratio of the number of emitted photons to the number of absorbed photons. It tells us about the fluorescent efficiency of the carbon dots prepared. Synthetic route and sometimes surface chemistry govern the quantum yield of CDs.

PREPARATIONS OF CARBON DOTS

GREEN SYNTHESIS OF CARBON DOTS

Recently studies have examined the green synthesis of CDs and discovered high salience. As we all know, carbon is found abundantly in nature and hence can be extracted by green synthesis. One such report mentioned the green synthesis of CDs' from orange peels using hydrothermal treatment (Prasannan and Imae, 2013) because it is a low-cost, sustainable way to make chemical compounds from environmentally favourable raw materials. Another study demonstrated a different technique for producing hydrothermal CDs from sugarcane bagasse, which has high carbon content and is thus regarded as a renewable resource since CDs can be made relatively easily (Liu *et al*., 2013). Utilizing greener techniques, CD synthesis recently improved. Using green chemistry instead of physical techniques simplifies the procedure and provides an environmentally friendly synthesis.

SYNTHETIC ROUTES FOR PREPARATIONS OF CARBON DOTS

The two main approaches for the synthesis of CDs are as follow (Fig 3.):

1. *Top-down:* Cutting carbon materials into carbon nanoparticles is known as top-down nano-cutting. This process often entails cutting various carbon resources, including graphite oxide or powder, carbon rod or nanotube, etc. Arc discharge, chemical ablation, laser ablation, microwave irradiation and electrochemical irradiation are examples of top-down nano-cutting techniques.
2. *Bottom-up:* This route includes dehydration and carbonaceous aggregation from small molecules. Sugar, bread, grass, glycerol, grains, potato, citric acid etc are used as carbon source. Bottom-up include thermal decomposition, microwave synthesis, hydrothermal treatment, plasma treatment etc.

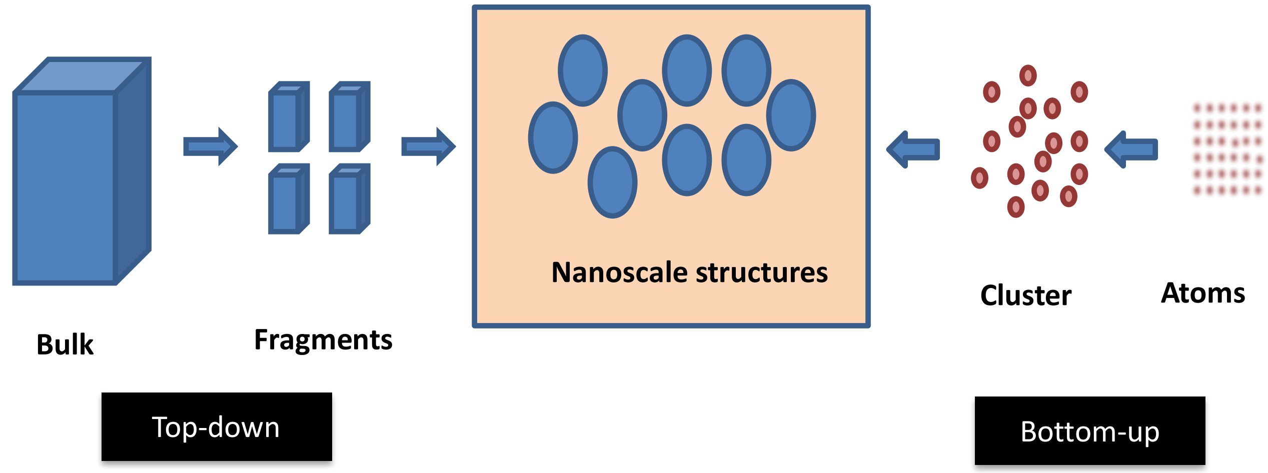

Fig. 3 Synthetic routes for the preparation of carbon dots

SURFACE MODIFICATIONS TO IMPROVE THE SURFACE PROPERTIES OF CDs

1. *Surface passivation:* CD surfaces have a high sensitivity to pollutants in their surroundings, making it possible for even very small amounts of contaminants to impact their qualities. Surface passivation of CDs is carried out to lessen the negative impact of surface contaminants on their optical characteristics. A thin insulating layer is often developed by attaching polymeric materials, such as oligomeric PEG, and PEG1500, to an acid-treated CDs surface (Fig 4). Effective surface passivation has been demonstrated to be a crucial step in producing CDs with high fluorescence intensities.
2. *Surface functionalization:* The functionalization of CDs is crucial because the addition of functional groups, such as amines and carboxyls, can produce various surface defects in CDs. Fluorescence emissions vary to a great extent as a result of these imperfections, which act as excitation energy traps. These cause an increase in the quantum yields (QYs) of CDs and alter the PL emission and the solubility in different solvents.

CHARACTERIZATION OF CARBON DOTS

Mostly for the characterization of CDs, we use High-Resolution Transmission Electron Microscopy (HRTEM), Raman spectroscopy, Fourier transform infrared (FTIR), X-Ray Diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS), Nuclear Magnetic Resonance (NMR), Matrix-Assisted Laser Desorption Ionization Time-of-flight (MALDI-TOF).

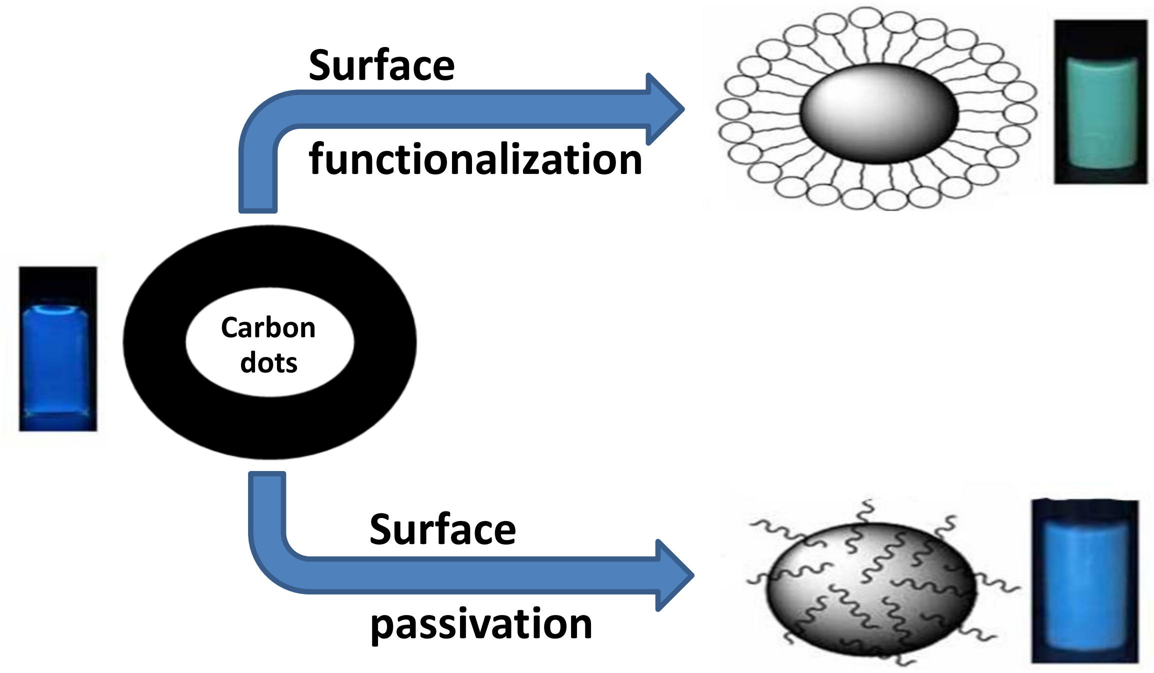

Fig. 4 Surface modifications in carbon dots

APPLICATIONS OF CARBON DOTS

1. **Biological applications:** CDs, a class of recently developed fluorescent nanomaterials, have demonstrated tremendous potential as adaptable nanomaterials for a variety of applications, including biosensing, bioimaging, drug delivery, photodynamic therapy, in vitro cell imaging, in vivo bioimaging, drug delivery, cancer therapy, enzyme activity modulation, cell membrane permeability, gene expression and antimicrobial application (Su *et al.,* 2021). Low toxicity and good biocompatibility of CDs are their most significant advantages for successful biological applications.
2. **Agricultural applications**: Due to high surface-to-volume ratios that give high sensitivity, sensors based on CDs are the most critical applications in pesticide detection. Based on CDs' fluorescence characteristics and surface functional groups, several biological and chemical sensors have been created. It is capable of detecting pesticides at levels that are far lower than some regulatory thresholds or standards. Furthermore, since they are so tiny and have a lot of surface functional groups and a high specific surface area, CDs are highly reactive and responsive to their surroundings. Therefore, the photoluminescence characteristics are mostly employed as superior detection probes.

ADVANTAGES OF USING CARBON DOTS

- Robust chemical inertness
- Chemical durability

- Easy accessibility
- Outstanding biocompatibility
- Low cost
- High resistance to photobleaching
- Good selectivity
- Simplicity
- Environmental compatibility
- Low or no toxicity

LIMITATION OF USING CARBON DOTS

- Lack of specificity
- Low quantum yield
- Unavailability of portable and miniaturized devices

CONCLUSION

Carbon dots (CDs), a new class of carbon-based nanomaterials, has gained growing interest in various scientific areas. The distinct photoelectronic and fluorescent properties, chemical inertness, an abundance of naturally occurring raw materials, ample supply of surface functional groups, facile functionalization, ease of synthesis, low or non-toxicity and environmental compatibility makes CDs well-positioned to achieve unprecedented performance. However, a detailed understanding of CDs' physical and chemical characteristics is still a major challenge owing to the complexity of CDs. Many crucial aspects, including structure, synthesis and optical qualities, are ambiguous, leaving open disputes and a non-uniform definition of their basics. The high photostability, great biocompatibility, straightforward synthetic methods, flexible designability, multicolour emission, deep red/NIR emission, and two-/multiphoton photoluminescence makes CDs the next generation of fluorescent probes.

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RICE FALSE SMUT (*VILLOSICLAVA VIRENS*) – SPORADIC DISEASE BECOMES EPIDEMIC

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ABSTRACT

False smut of rice was one of the minor and sporadic diseases worldwide. However, in recent days this minor disease is becoming a major concern causing huge yield loss and a reduction in the quality of the grains. The major reasons are changes in cultivar profile, including large-scale cultivation of high-yielding and hybrid varieties, intensive rice cultivation methods with high nitrogen demand, and climate change. However, epidemics vary significantly among types, fields, and cropping seasons. In addition, the severity of infection differs among varieties and growing conditions. Therefore, there is a need to develop suitable management methods for treating the disease to minimize direct economic losses.

INTRODUCTION

Rice (*Oryza sativa*) is prone to be infected by several plant pathogens, including fungal, bacterial, and viruses. Due to the climatic change, the rice crop is being devastated by minor diseases that earlier remained below the economic threshold. False smut, caused by fungal pathogen *Ustilaginoidea virens* (Cooke) Takahashi [teleomorph: *Villosiclava virens* (Nakata) Tanaka & Tanaka] is emerging as one of the potential threat to rice cultivation, replacing the whole rice grain into a blackish spore ball. Because of the sporadic nature of the disease, emphasis was not given in the past for managing this disease in India. In some parts of Southern India, it is popularly known as "Laxmi" disease and was believed to be a mark of a bumper harvest. However, from the year 2000 onwards, it has been reported as an epidemic disease and has become a major production constraint in several rice-growing regions in India. The disease infestation has increased due to the large-scale adoption of high-yielding and hybrid cultivars, intensive cultivation methods with heavy dependency on chemical fertilizers (high nitrogen) and apparent changes in climatic conditions. The disease occurrence has been reported in over 40 countries worldwide. In India, most rice-growing states *viz*., Punjab, Haryana, Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat, Jammu and Kashmir, and Pondicherry are reported to have false smut infestation. The intensity of the disease was so high that the release of spore mass in the atmosphere around the infested field caused a smoky black appearance. More than 50 smut balls per panicle could be seen in severe infection. Depending on disease intensity and prevalent rice varieties in different states of India, the yield loss due to false smut disease has been estimated between 0.2 to 49%. Infection by *V. virens* in rice causes sterility of the spikelets and reduces 1000-grain weight. The percentage of chaffy grains in spikes increases with the disease intensity. Around 10% of disease incidence caused about 25% chaffiness leading to a 9% reduction in 1000 grain weight and a reduced germination rate to 35%. This disease causes direct economic loss to the rice-growing farmers, and the pathogen also produces mycotoxin, i.e. ustiloxin, which is poisonous to humans and animals' health.

SYMPTOMS OF RICE FALSE SMUT

False smut is visible only after panicle emergence. In a rice panicle, the random infection could be seen in only some spikelets, which later converted into false smut balls. It can infect the spikelets during the flowering stage, and the infected spikelets have individual rice grains transformed into a mass of spore balls. At the early infection stage, it typically forms a white fungal mass protruding from the inner space of a spikelet. Later, it transforms into a smut ball of light-yellow-orange colour and turns into a greenish-black ball. Numerous chlamydospores are found on the outer layer of the mature smut ball, which is often covered by sclerotia in autumn. Apart from the infested grains in a panicle, the rest remain normal.

BIOLOGY OF THE PATHOGEN

False smut pathogen belongs to the kingdom: Fungi, phylum: Ascomycota, class: Ascomycetes, subclass: Sordariomycetes, order: Hypocreales, family: Clavicipitaceae, genus: *Villosiclava*, and species: virens and its anamorphic stage are *Ustilaginoidea virens*. The colony growth of *V. virens* is very slow in potato sucrose agar medium, with an approximate growth rate of 20 to 25 mm in diameter per week. The conidia of *V. virens* are hyaline, elliptical or oval, single-celled, having diameters ranging from 3 to 5 µm. Conidia may develop into rounded chlamydospores having prominent spines on the surface upon maturity or under unfavourable growth conditions. Sclerotia, which is the sexual structure of *V. virens*, can be formed in a smut ball. After passing several months of dormancy, sclerotia germinate and produce fruiting bodies from stromata, which ultimately generate ascospores.

EPIDEMIOLOGY AND DISEASE CYCLE OF RICE FALSE SMUT

Cloudy weather, high relative humidity (>90%), temperature ranging from 25-35 ºC and moderate rainfall during the flowering period favours disease development. Soil with high nitrogen content also favours disease development. The pathogen also survives through alternate hosts *viz.*, *Echinochloa crusgalli*, *Digitaria marginate*, *Panicum* sp. and *Imperata cylindrica.*

Fig 1. Disease symptoms of rice false smut: (A)–(C) yellow, orange and dark green false smut balls at early, middle, and late stages. (D) Colony of *U. virens* in PSA medium (E) Chlamydospores of *U. virens* from false smut balls (F) Conidia of *U. virens* in PSA

Villosiclava virens form chlamydospores and sclerotia late in the season, which fall in the soil and can survive for at least four months in the winter. Sclerotia germinate and produce ascocarp-containing ascospores, which act as a primary inoculum source for rice plants. In contrast, the chlamydospores are a secondary source of infection that may be coming from the airborne route. Rice spikelets get infected by *V. virens* at the late booting stage and produce false smut balls covered with dark-green chlamydospores. Occasionally, sclerotia are formed on the surface of false smut balls in late autumn when high day-night temperature fluctuation occurs. In this, both chlamydospores and sclerotia may serve as sources for primary infection. The occurrence of rainfall at the rice booting stage is a major environmental factor that causes epidemics of rice false smut disease. False smut galls emerge about 20 days after the initial infection of kernels in the rice panicle during flowering. This infection results in one or more kernels being replaced by globose, yellowish-green, velvety smut balls on mature heads of plants. It releases powdery dark green spores once it bursts open.

MANAGEMENT OF RICE FALSE SMUT

A successful management strategy for false rice smut is yet to be developed. However, the following measures should be taken as possible management strategies:

- Field sanitation- removal of weed hosts and plant debris
- Apply neem cake at 150 kg/ha
- Use disease-free seeds for sowing
- Seed treatment with *Pseudomonas fluorescence/Trichoderma viride* at 10 g/kg of seeds or Carbendazim at 2.0g/kg seeds before sowing.
- Avoid late sowing and application of higher nitrogen doses favours the development of disease
- Early planting of the crop should be done.
- Avoid monocropping and follow the crop rotation with non-host crops
- Foliar spray with *Pseudomonas fluorescence/Trichoderma viridae* 5g/lit of water at 15-20 days after transplanting or at the pre-flowering stage.
- At tillering and pre-flowering stages, Spray with Hexaconazole, Propiconazole, or Tebuconazole at 1ml/lit or Carbendazim + Mancozeb 2g/lit or Chlorothalonil 2g/lit.
- Application of copper oxychloride at 2.5 g/litre or Propiconazole @ 1.0 ml/litre at boot leaf and milky stage to prevent the infection.
- During harvesting, diseased plants should be removed and destroyed to avoid the fall of sclerotia in the field. This could reduce the build of primary inoculum for the next crop.

CONCLUSION

False smut of rice was one of the minor and sporadic diseases worldwide. It has become an epidemic due to changes in cultivar profile, including large-scale cultivation of high-yielding and hybrid varieties, intensive rice cultivation methods with high nitrogen demand, and climate change. However, epidemics vary significantly among types, fields, and cropping seasons. In addition, the severity of infection differs among varieties and growing conditions. Therefore, adopting suitable management methods for treating the disease can help minimize direct economic losses.

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CAPE GOOSEBERRY: POTENTIAL UNDERUTILIZED BERRY FRUIT OF INDIA

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ABSTRACT

Cape gooseberry (Physalis peruviana L) is an underutilized berry fruit grown in small pockets of Uttar Pradesh, West Bengal, Madhya Pradesh, Punjab and Jammu & Kashmir. It is a semi-shrub, semi-perennial in nature. Fruit is consumed fresh, dried to make raisins, and added to different functional foods. This berry fruit is highly nutritious, rich in vitamins, minerals, antioxidants and other bioactive compounds and has anti-diabetic, anti-cholesterolemic, hepato-protective, anti-inflammatory, and immunomodulatory properties. There is limited germplasm of Cape gooseberry available in India. There is an urgent need for germplasm introduction, cultivar selection, and to expand the area under cultivation for crop diversification and to ensure nutritional security.

INTRODUCTION

Physalis peruviana L. is a minor berry fruit of India belonging to the family Solanaceae. It is indigenous to the South American Andes, which include Peru, Brazil, Chile, Ecuador, and Colombia (Fischer and Melgarejo, 2014). This fruit was named after the "Cape of Good Hope" in South Africa, where it was first grown for commercial purposes (Chattopadhyay, 1996). It is also known by several names such as gigantic ground cherry, African ground cherry, Peruvian ground cherry, Peruvian cherry, Pok Pok (Madagascar), (Hawaii), Rasbhari (India), and many others. The berries are flavorful, tiny, lustrous, bright orange, sensitive, and encased in a calyx (a protective husk) (Puente et al., 2011). It has a high moisture content (78.9 g/100 g), protein (0.05-0.3 g/100 g), lipid (0.15-0.2 g/100 g), carbohydrate (19.6 g/100 g), fibre (4.9 g/100 g), ash (1.0 g/100 g), calcium (8.0 mg/100 g), phosphorus (55.3 mg/100 g), iron (1.2 mg/100 g), carotene (1.6 mg/100 g), thiamine (0.1 mg/100 g), riboflavin (0.03 mg/100 g), niacin (1.70 mg/100 g) and ascorbic acid (43.0 mg/100 g) (Hassanien and Morsel 2004). Uttar Pradesh, West Bengal, Madhya Pradesh, Punjab, and Jammu & Kashmir are the Indian states where it is grown. Farmers choose this fruit because of its attractive appearance, delicious flavour and scent, nutritional benefits, and high production per unit area. This fruit crop deserves special attention due to its tolerance to various agro-climatic and soil conditions, rapid growth patterns, high productivity, non-perennial occupation of land, and availability during the lean season,

BOTANY

Cape gooseberry is a semi-shrub between 1 and 1.5 metres in height with an erratic growth pattern and a semi-perennial nature that typically develops four upright, fruitful branches. The plant attains commercial fruit production during the first 18 months of the crop. Simple, heart-shaped, alternating, and pubescent leaves shield the plant from strong UV radiation from the tropical highlands and abrupt fluctuations in day/night temperatures. The blooms are solitary, hermaphrodite, and have a cupuliform calyx with five persistent sepals and a yellow tubular corolla (or modified leaves). These come together to create a husk about 4-5 cm long that encloses the fruit and shields it until it reaches maturity from pests, UV rays, rain, hail, and cold. Due to the breakdown of its chlorophyll and the translocation of almost all of its carbohydrates, especially during the first 20 days of the fruit's development, it then transforms into a translucent and parchment husk. Fruit matures in about 60 to 80 days, depending on the agroecological conditions. The fruit is spherical, yellow-orange, 1.25 to 2.5 cm in diameter, and weighs between 4 and 10 grams. The fruit has up to 350 small, lenticular, flattened seeds, each weighing about 1.1 grams.

Cape gooseberry fruit tied in clusters

Cape gooseberry fruits separately

SOIL AND CLIMATIC REQUIREMENTS

Cape gooseberry can adapt to a wider range of climate and soil conditions. Being a warm-season crop, it needs a long growing season to generate satisfactory yields. It can be grown effectively up to 1200 m in northern India and up to 1800 m in southern India. Although it can tolerate moderate cold up to 5 ˚C and higher temperatures (35˚C), it is believed that a temperature of about 21 ˚C is best for crops. The location should be bright, free of frost, and shielded from high winds for the plant. Because it is a delicate crop, it cannot sustain a severe cold. High humidity with high temperatures causes foliage diseases, and hot desiccating winds result in the dropping of blossoms (Phillip and Khan, 1952). Being a tender crop, it does not withstand a hard freeze. It can be grown in sandy to heavy clay soils and performs best in sandy loam, well-drained soil having adequate porosity for drainage and neutral pH (Chattopadhyay, 1996). Loams, clay loams and silt loams are preferred over lighter soils for the long growing season. Low-lying areas with poor drainage are not suitable for this crop.

PROPAGATION METHOD

Cape gooseberries are frequently grown from seeds. Another method of vegetative propagation is cuttings or layering. Around 150 to 200g of seed is sufficient for a planting of one hectare. Under north Indian circumstances, seed sowing in raised beds begins in mid-June, and transplanting follows after about a month of sowing during the rainy season. Cuttings treated with rooting hormones and measuring 10 to 25 cm in length are more successful than layering.

USES

The fruit is either eaten fresh (in deserts, salads, and as a garnish on a variety of foods and pastries), dried to make raisins, or processed to separate the juice and pulp from the seeds and peels (Singh et al., 2019). The fruit and the juice/pulp fraction are used to prepare jellies, jams, fillings, dressings, etc., because of the high pectin concentration and gelling qualities. It is also added to novel functional foods like yoghurt, ice cream, reduced-sugar goods, and diabetic foods (Valdenegro et al., 2013; Hegazy et al., 2019).

NUTRACEUTICAL PROPERTIES

According to several researchers, the fruit of cape gooseberry is a rich source of vitamins, minerals, carotenoids, polyphenols, phytosterols, reducing carbohydrates, pectin and other polysaccharides, as well as many other classes of functional compounds (Rodrigues et al., 2009, Puente et al., 2011, Ramadan et al., 2011, and Yldz et al., 2015). Its myriad phytonutrients and bioactive compounds further support its anti-diabetic, anti-cholesterolemic, hepato-protective, anti-inflammatory, immunomodulatory, antioxidant, and other effects, making it a superior functional meal (de Carrasco and Zelada, 2008; Hassanien, 2011; Puente et al., 2011; Ramadan, 2011; Eken et al., 2014; Lal et al., 2019; Singh et al., 2019).

INSECTS, PESTS AND DISEASES

The mite is the major pest which attacks this crop and may result in defoliation, which can be prevented by spraying wettable sulphur at 1.5 gm/litre of water. Powdery mildew and leaf spot are the two most significant diseases and can be managed with a spray of wettable sulphur at 1.5 gm/litre water, and 0.4% Filton spaced 15 days apart. If the plants are in poorly-drained soil or are left over from a previous year, they are vulnerable to viruses and root rots. Farmers, therefore, prefer biannual plantings. A tobacco mosaic strain also affects the crop in India. If not repelled, hares harm young plants, and birds (francolins) eat the fruits.

CONCLUSION

The need for horticultural crop diversification is urgent, seeing the present scenarios of increasing population and also for farmers with small land holdings, particularly in hilly states of India. For these farmers, Cape gooseberry can be a very good option because it ripens quickly after planting, has a short lag period and can be used as an intercrop in orchards because of its small stature and bushy habit. As a result, it is crucial to spread this fruit to areas of the country where the agro-climatic circumstances appear to be favorable for its growth.

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STABILITY OF FOOD FLAVOURS DURING PROCESSING

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ABSTRACT

Flavour is the sum of characteristics of any material taken in the mouth, perceived principally by the sense of taste and smell and the general pain and tactile receptors in the mouth, as received and interpreted by the brain (European Council). The different factors such as heat treatment, oxidation, enzyme activity, low pH and protein reactions play an important role in changing the flavour of the food. Controlling the different factors affecting the flavour may result into the stability of the flavour of the food products.

INTRODUCTION

Flavour is defined as the sum of characteristics of any material taken in the mouth, perceived principally by the sense of taste and smell and the general pain and tactile receptors in the mouth, as received and interpreted by the brain (European Council). Flavour is the entire range of sensations we perceive when we eat a portion of food or drink a beverage. It encompasses a substance's taste, smell, and any physical traits we perceive in our mouths, such as "heat" (for example, cinnamon) or "cold" (for example, spearmint) (FEMA). Flavouring products are added to food to impart, modify, or enhance the flavour of food (except flavour enhancers considered as food additives under the Codex.

TYPES OF FLAVOURINGS

Type	Description
Flavouring substance	Chemically defined substances are either formed by chemical synthesis or obtained from plant or animal-origin materials.
Natural Flavouring Complexes	Preparations that contain flavouring substances obtained by physical processes that may result in unavoidable but unintentional changes in the chemical structure of the flavouring (e.g. distillation and solvent extraction), or by enzymatic or microbiological processes, from the material of plant or animal origin.

Thermal Flavouring	Preparing for its flavouring properties by heating raw foodstuffs or constituents of foodstuffs. This process is analogous to the traditional home cooking of ingredients of plant and animal origin.
Smoke flavouring	Complex mixtures of components of smoke are obtained by subjecting untreated wood to pyrolysis in a limited and controlled amount of air, dry distillation or superheated steam, then subjecting the wood smoke to an aqueous extraction system or distillation, condensation, and separation for collection of the aqueous phase.
Flavour Enhancers	Substances are added to supplement, enhance or modify the original taste and aroma in food without impacting characteristic taste and aroma of its own.
Spices	Any aromatic vegetable substances in the whole, broken or ground form

IMPORTANT CRITERIA FOR UNDERSTANDING FLAVOUR STABILITY

- The composition of flavourings
- The raw materials
- The characterization of the flavouring.
- How to estimate flavour changes?
- The factors responsible for flavour changes.
- How to prevent flavour changes?
- Three factors influence the quality attribute of food aroma:
  a. The chemical reactivity of food flavour
  b. The environment of food, such as the availability of light and atmospheric oxygen and
  c. Food matrix system and its constituents, such as protein, fat, carbohydrate, transition metal, radical, and other polymers in food, such as brown melanoidins formed during the thermal processing of food.

FACTORS AFFECTING THE STABILITY OF FLAVOURS

The most important factors influencing the stability of flavourings are:

- Heat treatment (evaporation of volatiles, formation of new flavouring components)
- Oxidation (of terpenes, lipids), i.e. A high oxygen concentration, will make fat-containing products rancid
- Enzyme activity (degradation and formation of flavouring components)

- Low pH, i.e. A low pH, as in most beverages, will help acid-catalyzed reactions to occur, like hydrolysis of esters in an acid and an alcohol or acid-catalyzed rearrangements like citral into p-cymene fat absorption of liposoluble components
- Protein reactions.

VARIOUS ASPECTS OF FLAVOUR STABILITY

- **Physical stability:**
  - Evaporation of volatile components
  - Crystallization of non-soluble material (mainly in liquid flavourings)
  - Phase separation (in emulsions)
  - Solubility (in fat-containing food)
  - Absorption and adsorption effects in complex food systems
- **Chemical stability:**
  - Reactions with food components.
  - Reactions of Flavoring components through degradation, rearrangement, and oxidation.
- **Sensory stability:**
  - What is the standard sample to compare with (how is it stored?)
  - What does the customer expect and remember?
  - How does the customer evaluate the samples

EFFECT OF PACKAGING ON FLAVOUR STABILITY

The flavour stability will also be affected by packaging. A classic example is sun-struck flavour 3-methyl-2-butene-1-thiol (3-MBT or prenyl mercaptan) in beer (Blocksman et al., 2001). In the proposed pathway for 3-MBT formation, hop-derived isohumulones are decomposed to 3- methyl-2-butenyl radicals due to sunlight exposure. Likewise, sulfur-containing amino acids and proteins decompose to SH radicals through riboflavin-photosensitized reactions. These two radical types then combine and form 3-MBT.

CONCLUSION

Flavour is the sum of characteristics of any material taken in the mouth, perceived principally by the sense of taste and smell and the general pain and tactile receptors in the mouth, as received and interpreted by the brain (European Council). The different factors such as heat treatment, oxidation, enzyme activity, low pH and protein reactions play an important role in changing the flavour of the food. Controlling the different factors affecting the flavour may result in the stability of the flavour of the food products.

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NON-INVASIVE MONITORING OF ABIOTIC STRESS IN LIVESTOCK

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ABSTRACT

Abiotic stress in the form of temperature, humidity, wind speed and solar radiation is a major deterrent to livestock productivity. Conventional stress detection methods in animals have their limitations; hence, the adoption of non-invasive monitoring methods has gained momentum. Various non-invasive methods like visual observation, Temperature Humidity Index, Infrared Thermography, Internet of Things (IoT), hormone analysis, etc., have been successfully employed to monitor livestock's abiotic stress. The suitable method should be selected based on the animal type, cost, time and manpower involved to get the desired outcome.

NON-INVASIVE MONITORING

A procedure is defined as non-invasive when it does not involve using tools that break down the skin, and there is no contact with the mucous membrane or internal body parts beyond a natural body opening. In addition, non-invasive monitoring involves observing animals without disturbing their normal behaviour, ecology or physiology.

METHODS OF NON-INVASIVE MONITORING

ANIMAL BEHAVIOUR (VISUAL OBSERVATION)

Several symptoms elicited by animals can be visually observed to identify various stresses. Animals have difficulty breathing or irregular breathing due to heat or cold stress. Frequent urination by affected animals is another indication of stress. The heart rate increase is normally observed in stressed animals due to the release of adrenaline to cope with the situation. Huddling together is a unique symptom exhibited by animals exposed to cold stress. Slobbering, a condition in which saliva can be seen drooling from animals' mouths, is a clear indication of extreme heat stress. The method of visually identifying focus in animals is effortless and costs nothing. They do not involve the use of sophisticated tools or instruments. Even marginal and resource-poor farmers can observe the animals and identify the symptoms visually. Still, they need to be appropriately trained before making regular observations else there will be a misinterpretation of symptoms resulting in severe consequences.

TEMPERATURE HUMIDITY INDEX (THI)

It is a single value representing the combined effects of air temperature and humidity associated with the level of thermal stress (Bohmanova et al. 2007). THI has several merits; it is easier to derive since it involves only two parameters, i.e., temperature and relative humidity. Furthermore, the date required for THI is easily available through local weather stations. On the downside, they do not consider the influence of solar radiation and wind speed which plays a major role in altering the microclimate of the animals. In addition to that, the definitions of THI levels vary between indices and authors, leading to confusion as to which indices to be used for a particular species of livestock.

IR THERMOGRAPHY

Infrared thermography (IRT) is a non-contact, non-invasive modality capable of detecting heat emitted from a body surface as infrared radiation (Stewart et al. 2005). When an animal becomes stressed, the Hypothalamus-Pituitary-Adrenaline (HPA) axis is activated. This high release of hormones like adrenaline causes considerable changes in heat production, which can be detected using IRT. Infrared cameras come in different form factors and sizes depending on their intended purpose. They help in detecting thermal changes before clinical signs occur in the onset of many diseases. There are some limitations, like the cost of IR cameras being high. The image must be captured from wind drafts and direct sunlight to avoid stray pixels. Also, the hair coats should be free from dirt and moisture, which may interfere with the accuracy.

Fig 1. Infra-Red Imagery of Goats

RADIO TELEMETRY

It involves the process of recording and transmitting signals from a radio transmitter to a receiver for monitoring animals. It has three components: a transmitter, a radio receiver and an antenna system with a connected cable. Low to very high-frequency transmitters are used for monitoring animals that are confined in a small area. Radio telemetry devices can effectively monitor livestock's body temperature, body movement, heart rate and respiration rate. This technique is relatively inexpensive compared to sophisticated tools and provides for continuous or real-time monitoring of animals. On the other hand, it requires training for the installation and operation of the setup. In addition, data processing and interpretation need some expertise to make meaningful inferences.

INTERNET OF THINGS (IOT)

It is a combination of a network of sensors, software and other technologies that connect and exchange data with other devices and systems over the internet or other communications networks (Shinde 2017). The IoT sensors can be programmed separately using a software IDE and can be connected to a microcontroller unit. The communication network can be either through the internet or a Local Area Network (LAN). The most popular hardware manufacturers for IoT-based systems are Raspberry Pi, Arduino, Espressif, etc. Some popular IDEs are Arduino IDE, Eclipse, Netbeans, etc. IoT-based systems allow for real-time monitoring with minimal interference to animals. Furthermore, since there is a provision for storing the data in the cloud, there is a minimal risk of data loss.

On the other hand, IoT systems can get expensive depending on the components used. The sensors and microcontrollers are sensitive and fragile and must be handled with care. The setting up and operation of IoT systems require some knowledge of basic programming languages.

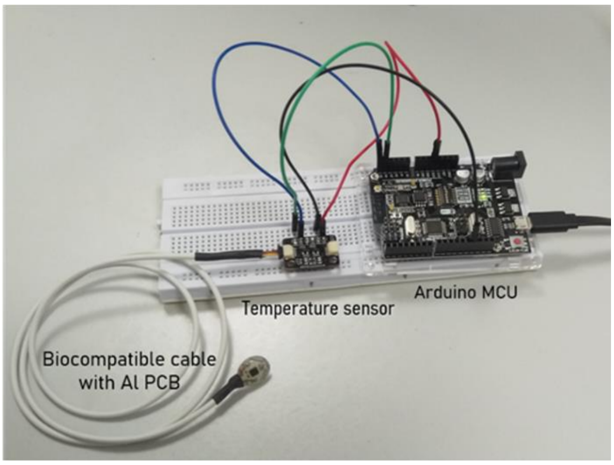

Fig 2. Arduino MCU connected to a temperature sensor

HORMONE ANALYSIS

Cortisol, a product of the hypothalamic-pituitary-adrenal axis, is released when the animals are subjected to stress. Hair Cortisol Concentration (HCC) is a retrospective marker of integrated cortisol secretion stress over long periods (Heimbürge et al. 2019). The effect of age on HCCs and cortisol incorporation into hair was found to depend on hair colour, body region etc. Faecal glucocorticoid metabolites (FGM) are widely used in controlled settings and is useful in detecting short-term stress response. Since gut microbial activity provides a direct glimpse of the interactions between the gut microbiome and its surroundings, this can be used effectively to monitor stress (Valerio et al., 2020). Hormone analysis has an easy and minimally invasive sampling procedure. They have an accurate, reliable and valid reflection of long-term cortisol secretion in animals. On the downside, it requires expensive instruments and chemicals for analysis. Also, scientific knowledge of the analytic procedure and instrument handling may restrict the usage to very few.

CONCLUSION

Though several methods are available for observing animals, no single method can be the best for animal monitoring. The selection of suitable methods or instruments is based on several factors, such as the type of animal under investigation, the cost involved, manpower requirement and time. Accordingly, the most optimum method or tools should be employed to get the desired outcome with minimal interference to the animal.

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MITIGATION STRATEGIES FOR GREENHOUSE GASES EMISSION IN AGRICULTURE

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ABSTRACT

Agriculture is one of the major sources of greenhouse gas emissions and thus contributes to global climate change. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the three most important greenhouse gases (GHGs), which are emitted mainly through livestock, irrigated rice fields and the application of nitrogenous fertilizers. So, understanding emissions and drivers is essential for the mitigation of GHGs. Agriculture offers potential opportunities for mitigating GHGs emissions largely through reducing N_2O and CH_4 emissions, carbon sequestration, soil and land use management, and biomass production. In addition, appropriate mitigation strategies can encourage farmers to adopt mitigation technologies without compromising yield and income.

INTRODUCTION

Agriculture is now facing challenges of increased food production, adapting to climate change and reducing greenhouse gas emissions. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the three most important greenhouse gases (GHGs) in agriculture. The biological breakdown of soil organic matter under aerobic circumstances and the disruption of soil and vegetation carbon reservoirs by tillage and ploughing are the principal sources of CO_2 emissions from agricultural soils. Submerged rice fields are the potential source of CH_4 produced by the microbial decomposition of organic matter under anaerobic conditions. Inorganic and organic nitrogenous compounds in soil, fertilizers, and manure are major sources of N_2O. With a goal of limiting warming to 1.5 °C, the 2015 Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) set a target to keep global warming far below 2°C. A significant reduction in emissions from the agricultural sector is needed to achieve this aim.

SOURCES OF GREENHOUSE GASES IN AGRICULTURE

1. Enteric Fermentation: Enteric fermentation, a digestive process by which microorganisms break down carbohydrates into simple molecules for absorption into the bloodstream, produces methane in herbivorous animals as a by-product. Methane is mostly produced by ruminant livestock (such as cattle, buffalo, goats, and sheep) and, to a lesser extent, by non-ruminant animals (e.g., pigs and horses).

2. Manure Management: Manure storage, treatment, and application to pastures all produce CH_4 and N_2O. Methane is produced when manure decomposes anaerobically during storage and treatment. Combining nitrification and denitrification of the nitrogen in the manure results in direct N_2O emissions. Volatile nitrogen losses during solid storage, primarily in the form of ammonia and NOx, cause indirect emissions.

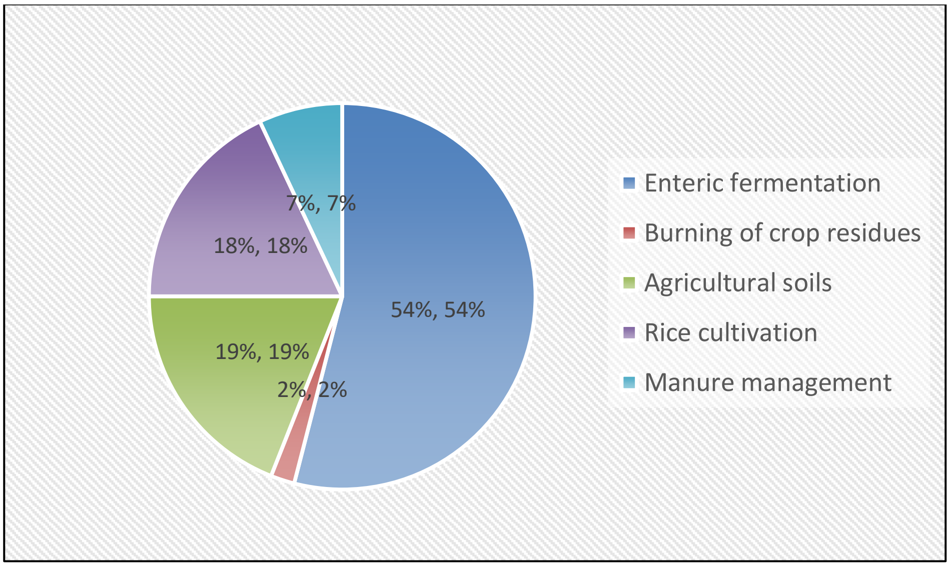

Fig.1. Sources of greenhouse gases emission in agriculture

3. Rice cultivation: The bacterial breakdown of complex organic materials results in the production of CH_4 in the anaerobic environment of the flooded rice ecosystem. Methanogens are the bacteria/archaea engaged in this process, also known as methanogenesis. The majority of methane released into the atmosphere by rice plant aerenchyma tissues. The duration of the crop, the watering schedule, and the addition of organic soil amendments all affect the annual quantity of CH_4 released from a particular area of rice.

4. Agriculture soils: There are two pathways of N_2O emissions from soils - direct and indirect. Direct N_2O emission was estimated using net N additions to soils (synthetic or organic fertilizers, deposited manure, crop residues) and mineralization of N in soil due to cultivation/land-use change on mineral soils. The indirect N_2O emission was estimated from the volatilization of NH_3 and NOx from managed soils and the subsequent re-deposition of these gases and their products (NH_4 and NO_3) to soils and after leaching and runoff of N, mainly as NO_3 from managed soils.

5. Burning of crop residues: Carbon monoxide, CH_4, N_2O, Nitrous oxides, and a variety of other gases are produced when crop residue is burned in the fields. Due to their widespread production throughout the nation, residues from eight crops-rice, wheat, cotton, maize, millet, sugarcane, jute, rapeseed, and mustard are typically burned in the field.

STRATEGIES FOR MITIGATING GREENHOUSE GASES EMISSION

A. Mitigation of methane emission from rice field

- Alternate wetting and drying (AWD)- the practice of flooding a farm field, letting it dry until the top soil layer begins to dry out, and then repeatedly flooding and draining the area throughout the season.
- Direct rice seeding (DSR)
- System of rice intensification (SRI)
- Screening of rice cultivars with few unproductive tillers, high root oxidative activity, and high harvest index.
- Rice straw management through off-season application under dry soil conditions, composting, turning rice straw into biochar and better nutrient management
- Applying fermented manure like biogas slurry in place of unfermented farmyard manure.

B. Mitigation of nitrous oxide emission

- Enhancing N use efficiency with the use of the right kind of fertilizer applied with the right method at the appropriate rate, time, and place
- Demand-driven N use using a leaf colour chart (LCC)
- Use of manure or integrated use of manure and fertilizer to reduce reliance on chemical fertilizer
- Application of N based on soil test and use of technologically advanced fertilizers such as slow-release fertilizers or nitrification inhibitors such as coated calcium carbide and dicyandiamide
- Plant breeding and genetic modifications to increase the N uptake

C. Sequestration of carbon in agricultural soils

Carbon sequestration is the long-term capture and storage of carbon in the soil, water, vegetation and engineering structure that would otherwise be emitted to the atmosphere. Terracing, contour strips, and cover crops can be used to avoid soil erosion and preserve the carbon that is already present in the soil by slowing the pace at which organic matter decomposes. By keeping agricultural wastes on the soil, cultivating perennial plants with larger root systems, using slow-degrading carbon sources like biochar, and integrating and balancing the usage of plant nutrients, the system's carbon content can be increased.

D. Reducing emissions from ruminants and manure management

Feeding should be improved with more efficiency to cut emissions, and manure management procedures should be followed. Feeding efficiency is improved by forages and dietary supplements that suppress methanogenesis. Livestock diets are improved with the addition of supplements and additives to feed. Methane can be produced by the anaerobic fermentation of manure in biogas digesters and utilized as fuel or turned into energy. So, effective manure management and its soil application decrease the need for synthetic fertilizers, replace fossil fuels, provide marketable goods, and boost crop and pasture productivity, lowering GHG's emission intensity.

E. Genetic enhancement of crops and animals

It is necessary to investigate how to find features in a genome that will boost output and reduce emissions. Most research to date has concentrated on decreasing anti-nutritional factors in feed, improving feed palatability, and raising feed conversion ratios (FCRs).

F. Enhancing input-use efficiency and conservation agriculture

The efficiency of agricultural inputs such as water, nutrients, pesticides, and labour is low in agricultural production. This causes more losses and GHG emissions. Increased mechanization in agriculture and increased use of resource-conserving technology, such as those that save water, labour, and nutrients, can minimize waste, enhance revenues, and reduce greenhouse gas emissions. Farmers can reduce GHG emissions and earn money by implementing some of these technologies. Additionally, using agricultural feedstocks instead of fossil fuels to produce electricity can decrease GHG emissions.

CONCLUSION

The agriculture sector shares a major proportion of total GHGs with carbon dioxide, methane and nitrous oxide emissions. Mitigation of GHG emissions from agriculture can be mitigated by sequestering carbon and reducing the emissions of methane and nitrous oxide emissions through changes in land-use management and enhancing input-use efficiency. A win-win solution would be to develop mitigation strategies that help adapt to climate change and promote sustainable agricultural development.

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