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Homestay tourism: Integrating tradition and modernity

Deepali Rawat, Rahul Singh Saun, Neelam Bhandari

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Pithoragarh

Home-stay is an innovative idea in the tourism and hospitality sectors that is seen to be the finest alternative to staying at a hotel. In contrast to hotel accommodations, homestays allow tourist to experience the land, people, culture, and food of any location in its entirety. Different sorts of residences are turned into homestays, such as vintage homes, farm houses, property bungalows, ancestral homes, and so on, affording a peaceful stay away from filled towns and cities but close to tourist sites. Houses located on ranches or orchards in isolated areas are commonly referred to as home stays. In order to accommodate a few guests, residents in those locations have converted their farm houses, heritage homes, or hill cottages. These visitors can dwell in a cozy setting and have the possibility for interaction with other local families, who serve as the hosts' primary hosts. In certain locations, numerous families are housed in one location.

In India, the phrase "**Athithi Devo Bhava**" means "**the guest is God.**" Having visitors in their home is a great honour for Indians, who make a special effort to make them feel welcome. The good news is that, as homestays become more and more popular in India, all of this is changing. Visitors are either housed in the family home or in separate, adjacent accommodations. These days, the majority of homestays give their visitors the same level of comfort as a respectable hotel. It may be better to stay at a homestay rather than a hotel. There are various types of home stays available depending on the location. They are found in plantations, next to beaches, and even in some villages. The fundamental idea of home stays is universal, even though the locations may differ. Additionally, visitors can spend a day or two in a boat house, where they can relax on the decks, ride a bullock cart, use a tractor to plough a field, work alongside the plantation workers, and take part in local celebrations. Some home stays provide their visitors with the opportunity to learn

about local cuisines in addition to serving local specialties in their meals.



Opportunity for a home stay—a vacation with a local flair and a home away from home!

Although the idea of a home stay opportunity is well-liked throughout the world, it hasn't gained much traction in India because of our ingrained feelings of insecurity and communication

concerns with foreign visitors; the demands on privacy that one may have to give up; our lack of knowledge about how to organize, provide, and manage house guests who are expected to follow house rules, pay for their meals, and stay; and the fact that the majority of traditional Indian homes still use a joint-family system, which requires that the diverse personalities of various family members be taken into consideration before welcoming temporary members. In addition to providing the local inhabitants with a steady source of income, homestays help preserve the area's natural and cultural history. The tourists' experience is enhanced by various activities they like in addition to spending time at home with their families. Depending on the location, the package includes activities that tourists enjoy, like fishing, bird watching, cycling through rural areas, trekking through neighbouring forests and hills, toddy tapping, pot-making, riding elephants, local art performances on re-request, and many more. A recent development in the travel industry is the home stay. It is a possible economic activity in the travel and tourist industry. Due to its cultural features, it gains popularity among tourists who want to learn about and engage with the locals.

Principles for the development of rural tourism and homestay

1. Development of infrastructure.
2. Policy reform and liberalization.
3. Encouragement to invest.
4. Police for Tourists
5. Law and Order
6. Tourism Police
7. Handling complaints.
8. Standardization for products and services.
9. Government support.
10. Rural tourism can promote sustainable development in rural communities

Homestay's advantages for rural tourism promotion

- **Distinct and Unique Accommodations**
Staying in a homestay is the best way to see India's immense charm and diversity. There are

several possibilities, such as isolated countryside cottages, antique havelis (mansions), and plantation bungalows.

- **Tailored Support**

There are typically fewer rooms in a homestay than at a hotel. It is run and hosted by the family who lives there. Living with an Indian family is, in any case, the simplest method to learn about Indian culture and lifestyle. After the holiday is finished, many hosts and guests discover that they have a strong bond and stay in touch.

- **Knowledge of the Local Area**

Picking what to see and do is made easy by the hosts' extensive knowledge of their neighbourhood. To get the most of your trip, such local knowledge is quite beneficial. A lot of hosts are delighted to give their visitors a tour of their neighbourhood, giving them priceless insights that aren't found in a guidebook.

- **Home-cooked meals**

The Indian food prepared in an Indian home and the food offered in hotels and restaurants differ greatly. You will have the opportunity to sample real Indian home-cooked, freshly prepared meals while staying at a homestay. It is much lighter than restaurant cuisine and has more flavor and



variety. Guests are also invited into the kitchen of some homestays, where they may observe and take part in the culinary process.

Distinctive Recreational activities

During a homestay, the emphasis is on you and your tastes. The hosts will go out of their way to make sure you have things that interest you and are typically quite flexible. The activities will change based on where you are. Some of the alternatives include visiting a coffee farm in Coorg, going to a polo match in Rajasthan, herding animals in isolated northern India, and taking part in village visits, picnics, and temple excursions.

Challenges pertaining to homestay and rural tourism

Preserving the environment and natural resources, educating and properly understanding both tourists and locals, focusing on occupation training, promoting handicrafts, and improving the landscape and basic infrastructure are the main challenges. By creating a healthy environment,

they also hope to improve the quality of life for the villagers. Using a cooperative framework to promote homestays and rural tourism can be a good way to improve rural communities. With equal stakes and authority in development and management, locals may keep an eye on and mitigate the detrimental effects of tourism on their own society. The major challenges are enlisted below;

- Statutory Issue and lack of Skilled Workers
- Inadequate Funding
- Absence of Local Participation
- People who are not yet developed
- Insufficient physical communication
- Insufficient Basic Schooling
- Competencies in Business Planning
- An experienced tour guide
- The knack to Communicate

Nature's gift, Her Talent

Suman Panthri

Vill- khanda, Block- Kaljikhhal, Pauri Garhwal

From Pine Needle and Pine Cone, Suman ji makes many products like baskets, wall clocks and other decorative items. Pirul is also called Pine Tree. She wants that we should use Pirul in a good way to make useful products so that women of the village can get employment. And no one should consider Pirul as useless and use it to make good decorative and useful products.

Suman ji is from vill- Khanda, Block- Kaljikhhal, Pauri garhwal. but she currently resides in Ghaziabad. Suman Ji uses pine trees to make her own products. She has a master's degree and a bachelor's degree in education, but she never had a job before. She tells that earlier she used to make thread jewelry for herself from the waste material. She says she resides in Ghaziabad with her family. She says that when she visited her village the previous year, she noticed that the mountains in front of her were on fire, and the fire continued to burn all night. She then realized that she should attempt using this Pirul for something different because it is not an important material. She then attempted to make it back to Ghaziabad with some Pirul that she had brought with her. She then gave it an attempt and while it was somewhat successful, she was having trouble molding and finishing. She then attended a two-day training course to learn molding and finishing. She then began working at her home in a proper manner.

She spent two months at work. Additionally, she didn't bring much Pirul from her hometown, so if something was even slightly broken, she would constantly open and sew it in order to prevent wastage. After she

eventually mastered finishing, she began crafting pirul jewelry, flower pots, and baskets etc. She wanted to try something else after that. Since she had previously observed other Kumaon region ladies performing this activity. She then attempted to create various items, such as wall clocks. She took a long time to make it there. Because it is so soft, the



Pirul breaks easily. She took the time to go over the material for it so that it is tight and has an appealing appearance. After that when it was made, she started manufacturing things from different materials from pine cone.



She took the 2-day training from Geeta Pant ji in Almora. She says that she has been doing craft related work for a long time but it has been 3-4 months since she started working with Pirul. She says that she makes wall clocks, jewellery, finger ring plates, pen stands, flower pots etc from Pirul order pine cone.

She tells that when she was starting this work, she brought Pirul in very less quantity. But now as she is making proper things, she goes to the village every 2 to 3 months so that she can bring it again and again.

Procedure

She tells that she makes these products with the help of Pirul and thread. Pirul is first soaked in water to make it flexible and many times she starts her work without even soaking it. To make any product, she uses Pirul, thread, colorful thread and other craft products like mirror, artificial flower etc.

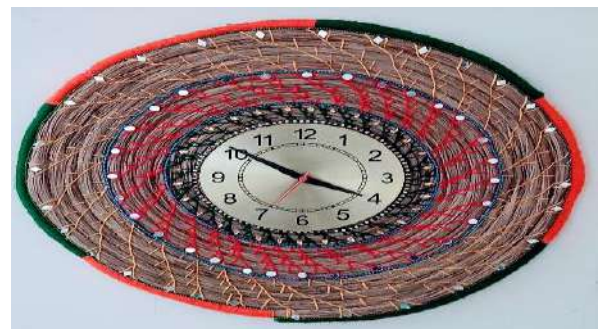
Marketing, pricing and selling

Right now she has not got any affiliation from any government. But she wants to get affiliation from the government through which she can go to villages and teach this work to other women as well. She says that although she didn't used to promote her own items, these days she does so to her friends

and relatives. As more people became aware of her items, a chain began to take form and she is currently managing this project in Ghaziabad. She sells the orders there after determining the demand for the products. She sets her product prices based on market demand. Her wall clocks are priced according to their diameter; for instance, a 14-inch watch costs Rs 600, while a 15-inch clock costs Rs 800. As of now, she has only created circular clocks, though she is attempting to create other shapes as well.

Major problems

Her main issues are that she says that the



hardest part of opening and cutting a pine cone is doing so. Due to their extreme sharpness and softness, pine needles present greater issues than pine cones. Additionally, it can be difficult to handle them properly, even when they irritate.

Help from Government

She now demands a government platform. so that orders for the goods she is producing can reach the people as well as just her. And she receives appropriate direction. Additionally, awareness is given to people.

Article by:
Akirity Rawat

The Red Cotton Tree: A Natural Guardian

Kiran Patwal, Himani Jyala, Dimpal Chand

**Department of Agriculture, Pithoragarh group of institutions Bungachhina,
Pithoragarh**

***Bombax ceiba** commonly known as semal is a remarkable species that thrives in the forests of India, Nepal, Bangladesh and Myanmar. Known for its striking red flowers and broad canopy, this tree doesn't just beautify the landscape but is also a powerhouse of medicinal, ecological and medicinal properties.*

It's a deciduous tree that grows upto the height of 30 m tall and has a broad canopy that gives plenty of shades. Its bark is thick and the trunk is frequently spiky, giving it a unique appearance. Known by many names such as semal, tukka, sal, kopak, salmali, Rakshita Puspha and the resemblance of its flowers colour to the vibrant colour of silk and the cotton -like texture due to which it is also known as Red Cotton Silk. These blooms are not only visually appealing but they also attract a diverse range of pollinators including bees, birds and bats. It's an unsung hero when it comes to supporting the environment and local communities.

The significance of this tree also can be traced back to Vedic times where it was considered an essential part of the Panchwati and honoured as "God tree". The Semal tree has a deep-rooted significance in ancient Indian traditions, especially during Vedic times. These groves were believed to attract positive energy or "microvita," which was thought to support spiritual growth. People in ancient times would gather in these groves to meditate and connect with their inner selves, using the serene environment to deepen their spiritual

practices. In contrast, Caribbean tradition tells an alternate tale with the tree known as the "Jumbies Tree," which is thought to attract the spirits of the dead and it is thought that Loogaroo (vampires) find shelter on this tree.



Nutritional components of Semal tree

The tree's entire structure is nutrient-dense, and when used appropriately, it can provide a considerable source of income for producers.

Seeds:

Semal seeds have a substantial amount of oil between 20 and 25 %. It is also used in some industries as a substitute for cotton seed oil such as in soap oil. The seeds also have anti-inflammatory and antiseptic qualities. They

can be used for the treatment of fever, diarrhoea and even skin conditions. It also plays an advantageous role in agroforestry methods as it can also increase soil fertility particularly in tropical and subtropical areas.

Leaves:

The leaves of the *Bombax ceiba* tree contain shamimin a flavonol C- glycoside which is particularly effective in help in lowering blood pressure. The juice of the leaves can also be used for the treatment of conditions such as rashes, boils, ulceration of the kidneys and bladder, chronic inflammation and includes type of dysuria and stranguria.

Bark:

The strength and fibrous texture of bark make it perfect for crafting ropes, baskets and mats. The bark is also used for in medicines for the treatment of bacterial infection, kidney stone, heart tonic, headache and snake bite.



A glimpse of future for Semal tree:

With the growing shift of the industries and consumers towards sustainable and eco-friendly products, the use of the semal based products can play a vital role in fulfilment of demands in agricultural and in food technology companies. The Society for Microvita Research and Integrated Medicine

(SMRIM) for the past 11 years has been working on conservation of this tree in Udaipur.

Bombax ceiba has an energy value of 322 k calories and is composed of 71% carbs, 7% proteins, 1% fat, fibre (19%), iron, zinc, calcium, magnesium, sodium and copper are all abundant in it. In addition, it also has trace levels of riboflavin, pantothenic acid and ascorbic acid. The fibers from the fruit can be processed and used as a natural thickener or texturizer in food preparations. These fibers are nutrient dense and could be used in functional food compositions. The presence of high dietary fibre, protein, carbohydrates and amino acids can be incorporated into the plant-based protein products, energy bars, ready to eat meals and protein bars. They can also be a great source for the plant-based food industry. The carbohydrates in Semal fruit can be processed into natural sweeteners making them ideal for the growing demand for natural and organic ingredients. The flowers, timber and seed oil from the *Bombax ceiba* tree are also of commercial valuable. Seed oil is used as edible oil and employed in the manufacturing of soap while timber is used to construct matchsticks, vermin-proof thread for filling upholstery and life-saving equipment. The carbon sequestration capability of the Semal tree may also become more commercially significant as governments and organizations invest in carbon credits and climate change mitigation methods. Planting and keeping Semal trees in forestry initiatives can produce revenue from the sale of carbon credits, which benefits both the environment and local economics. Hence, the Semal tree is of valuable resource with both ecological and

cultural significance, offering great potential for sustainable practices, medicinal uses and conservation. By investing in the tree's preservation and development, we can not

only help protect our ecosystems but also create economic opportunities for farmers for improving livelihood in rural communities.

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Roots of Success: A Woman Journey in Integrated Farming

Meena Rana

Village- Khatli Kimana, Block- Jakholi, Distt- Rudrapryag

Meena ji cultivates vegetables in her village's fields. Her primary objective is to eliminate the barren land around her using his traditional, traditional agricultural knowledge. She also wants to provide work for the people living in his town and make future improvements even better for them.

Mrs. Meena Rana is a resident of village Kimana, Block- Jakholi, Dstt- Rudrapryag. Presently, she cultivates vegetables in her village, in addition to raising fish and poultry. She indicates to have worked in agricultural for 20 to 22 years, although the last 15 of those years have been spent producing vegetables. She lives in a small village of Uttarakhand and is mostly a housewife. According to Meenaji she works alone on this work and she is not very educated either. She wanted to study but due to some reason she had to leave it and she got married. She used to live alone in the village while her husband worked in the private sector. Then her husband relocated to the the village and started working in agriculture, quitting his job in the private sector. She claims that although this work requires a lot of effort, but everything is pure. She says that she came across an NGO called Jalagam, under which good quality seeds were provided to her, as of right now, there is no government program through which she is getting any kind of help for producing vegetables.

She also works for the Hans Foundation, an NGO that is funded entirely by donations. Furthermore, Meenaji is in charge of 7 villages, each of which has 9 groups with

100–150 women. As an active member of organisation Meenaji gives these women agricultural livelihood training and provide seeds. Additionally, she handles any agricultural-related issues that arise.

She is connected to the NRLM, another government program. She also participates in the government-sponsored NRLM, a livelihood project. In this, people open bank accounts and receive funds to purchase seeds by traveling to the communities. She has recently signed up for this program.



She explains that although there is a lot of danger from other wild animals to the vegetables in her area, she manages it herself

and plants potatoes, onions, garlic, peas, and other crops there. Now people come to her house to buy vegetables because she grows the vegetables organically. She uses organic compost, such as manure from cow dung. She tells that none of the surrounding villages



grow vegetables. Therefore, ever since they began this work, people come to their home to buy vegetables on their own.

She first started production of potatoes and the harvest was good, she prices her vegetables based on the cost of the seeds. For example, she currently sells ridge gourd, pumpkin, garlic, and lauki for 40 rupees per kg to customers who visit her home. If she decides to sell these vegetables at the market, she also includes the cost of the vehicle rent. She says that, she supplies these vegetables to the market on demand. Her harvest of garlic was estimated to be between one and two quintals, of which she sold nearly all at home at a price of Rs 120 per kilogram, while the price of the garlic she sold at the market increased to over Rs 200 per kilogram.

She has only been in fish farming for 5 or 6 months, and during the period she has kept

crowded fish. Fish farming is currently covered by a government program. They received Rs 50,000 from the government for their fish farming. They take care of all other necessities, such as food and fish farming, on their own.

Problems

- She's unable to receive the seeds on time is her main issue. She claims that she rarely receives high-quality seeds on time.
- She says that she has no knowledge about any insect, pest or any disease in the field which spoils her crop.
- She says that their village does not have well developed roads due to which she has to herself carry the production to the market by her own.
- One man must watch over the field all day because a wild animal causes damage to the crop.

Expectation from govt.

- She states that she wants the government to provide training for women in rural areas. She wants that women who farm in the community receive instruction in managing insects, pests, and diseases of the crops.
- She says that because they do not now have access to farm machinery, they are facing many difficulties. According to her, they are severely lacking in technology.
- They lack the knowledge and skills to plant any new crop that they haven't already planted. They demand to know everything there is to know about this.

Article by:
Akirity Rawat

जलवायु परिवर्तन: जलवायु-रोधित फसलों का उदय और अनुकूलनशील कृषि की नवाचार रणनीतियाँ **निहारिका एवं चंद्रकांत**

¹ बीज विज्ञान और प्रौद्योगिकी विभाग² फल विज्ञान विभाग

डॉ. यशवंत सिंह परमार बागवानी एवं वानिकी विश्वविद्यालय, नौणी, सोलन

जलवायु परिवर्तन आधुनिक कृषि के लिए एक बड़ी चुनौती है, जो जनसंख्या वृद्धि और मिट्टी के क्षरण से और भी बढ़ गई है। 20 वीं सदी की हरित क्रांति ने उच्च उपज वाली फसलों और तकनीकी प्रगति के माध्यम से खाद्य सुरक्षा को बढ़ाया, लेकिन साथ ही जैव विविधता हानि और जल प्रदूषण जैसे पर्यावरणीय परिणामों को भी जन्म दिया। जैसे-जैसे औद्योगिकीकरण, वनों की कटाई और जीवाश्म ईंधन के दहन के कारण जलवायु परिवर्तन में तेजी आती है, ग्रीनहाउस गैस उत्सर्जन में वृद्धि से गर्मी फंसती है, वैश्विक तापमान बढ़ता है और सूखे, बाढ़ और हीटवेव जैसी चरम मौसम की घटनाएँ तेज होती हैं। ये परिवर्तन फसल वितरण को बदलकर, पैदावार को कम करके और कीटों और बीमारियों को बढ़ावा देकर कृषि को खतरे में डालते हैं। जबकि बढ़े हुए CO₂ स्तर कुछ क्षेत्रों में पौधों की वृद्धि को बढ़ावा दे सकते हैं, वे फसल की गुणवत्ता और स्थिरता से भी समझौता करते हैं। इन प्रभावों का मुकाबला करने के लिए, जलवायु-स्मार्ट कृषि (CSA) उभरी है, जो टिकाऊ

प्रथाओं, बेहतर लचीलेपन और जलवायु-लचीली फसलों के विकास को बढ़ावा देती है, जो पैदावार को बनाए रखते हुए कठोर परिस्थितियों का सामना करने के लिए डिज़ाइन की गई हैं। जलवायु परिवर्तन से निपटना वैश्विक खाद्य आपूर्ति को सुरक्षित रखने और दीर्घकालिक पारिस्थितिक स्थिरता सुनिश्चित करने के लिए महत्वपूर्ण है।

जलवायु परिवर्तन का कृषि पर प्रभाव:



जलवायु परिवर्तन कृषि क्षेत्र पर तीव्र प्रभाव डाल रहा है, और इसके परिणामस्वरूप किसानों को विभिन्न चुनौतियों का सामना करना पड़ रहा है। बढ़ते तापमान, बदलते वर्षा पैटर्न, और चरम मौसम घटनाएँ कृषि उत्पादन को प्रभावित कर रही हैं। नीचे जलवायु परिवर्तन के प्रमुख प्रभाव

और उनके कृषि पर परिणामों का विवरण दिया गया है:

बढ़ती परिस्थितियों में बदलाव:

बढ़ते तापमान और अप्रत्याशित वर्षा से फसल चक्र में गड़बड़ी होती है और पैदावार कम होती है। अल नीनो जैसी घटनाएँ सूखे का कारण बन सकती हैं, जिससे मिट्टी की नमी कम हो जाती है। हीटवेव और बाढ़ जैसी चरम मौसम की घटनाएँ खेती को और भी मुश्किल बना देती हैं। ये बदलाव किसानों को बदलते जलवायु पैटर्न के अनुकूल होने के लिए मजबूर करते हैं।

उच्च रोग जोखिम:



गर्म तापमान और आर्द्रता कीटों और पौधों की बीमारियों के लिए आदर्श परिस्थितियाँ बनाते हैं। गेहूँ की जंग और तुषार जैसे फंगल संक्रमण नए क्षेत्रों में फैल रहे हैं, जिससे नुकसान बढ़ रहा है।

खरपतवार वृद्धि में तेजी:

कार्बन डाइऑक्साइड (CO₂) का स्तर बढ़ने और तापमान के उच्च होने से खरपतवारों की वृद्धि तेज हो रही है। यह खरपतवार फसलों के साथ प्रतिस्पर्धा करती हैं और उन्हें पोषक तत्वों, पानी और सूर्य की रोशनी के लिए चुनौती देती हैं। कुछ खरपतवार जलवायु परिवर्तन के अनुकूल हो रहे हैं, जिससे उनका प्रसार और वृद्धि तेज हो

रही है। इस बदलाव के कारण, खरपतवारों को नियंत्रित करना कठिन हो रहा है, और शाकनाशियों का अत्यधिक उपयोग करने से प्रतिरोधी उपभेद विकसित हो गए हैं, जिससे उनकी प्रभावशीलता घट रही है। इसका परिणामस्वरूप खरपतवार नियंत्रण की लागत और प्रयास बढ़ रहे हैं।

फसल विफलताओं में वृद्धि:



फसल विफलताओं में वृद्धि चरम मौसम, बदलते मौसम और कीटों का प्रकोप फसल विफलताओं में योगदान देता है। सूखे के कारण जल संकट पैदा होता है, जिससे पैदावार कम होती है और खाद्य सुरक्षा को खतरा होता है। बाढ़ से मिट्टी और फसलें क्षतिग्रस्त होती हैं, जिससे सुधार मुश्किल हो जाता है। इन चुनौतियों के कारण खाद्य कीमतें बढ़ जाती हैं और किसानों के लिए आर्थिक मुश्किलें पैदा होती हैं।

खेती के क्षेत्रों में बदलाव:

बढ़ते तापमान और बदलते वर्षा पैटर्न के कारण फसल उगाने के स्थान में बदलाव हो रहा है। पारंपरिक खेती के क्षेत्र अब अनुपयुक्त होते जा

रहे हैं, जबकि नए क्षेत्र खेती के लिए अधिक उपयुक्त बन रहे हैं। इस बदलाव से स्थानीय खाद्य प्रणालियाँ प्रभावित हो रही हैं, और किसानों को नए क्षेत्रों में अनुकूलन करने की आवश्यकता है। खाद्य असुरक्षा से पहले से प्रभावित क्षेत्र इन बदलावों से सबसे अधिक प्रभावित हो रहे हैं।

भारी धातु संदूषण:

जलवायु परिवर्तन से मिट्टी में भारी धातुओं का फैलाव बढ़ रहा है। उच्च तापमान और अत्यधिक वर्षा फसलों में धातु संदूषण फैलाती है। इन धातुओं के पौधों द्वारा अवशोषित होने से पैदावार घटती है और मानव तथा पशुओं के लिए स्वास्थ्य जोखिम उत्पन्न होते हैं। यह संदूषण खाद्य सुरक्षा और कृषि स्थिरता को प्रभावित करता है।

जल संबंधित समस्याएँ:

जलवायु परिवर्तन सूखा और बाढ़ दोनों को बढ़ावा दे रहा है, जिससे पानी की उपलब्धता प्रभावित हो रही है। बढ़ते तापमान के कारण वाष्पीकरण बढ़ जाता है, जो शुष्क परिस्थितियाँ उत्पन्न करता है, जबकि जलभराव से फसलों को नुकसान हो रहा है। अप्रत्याशित जल चक्रों के कारण सिंचाई प्रबंधन कठिन हो गया है, और यह किसानों के लिए एक बड़ी चुनौती है।

आर्थिक दबाव:

सिंचाई, कीट नियंत्रण और मिट्टी प्रबंधन की बढ़ती लागत किसानों के वित्तीय बोझ को बढ़ा रही है। चरम मौसम घटनाओं और अप्रत्याशित पैदावार के कारण आर्थिक जोखिम बढ़ रहे हैं,

जिसके परिणामस्वरूप किसानों की वित्तीय स्थिति कमजोर हो रही है। यह स्थिति कृषि में निवेश में कमी ला रही है, जिससे किसानों के लिए स्थिरता बनाए रखना मुश्किल हो रहा है।

जलवायु-लचीला कृषि उपाय:

इन समस्याओं से निपटने के लिए कई नवाचार और उपाय विकसित किए गए हैं जो कृषि को जलवायु परिवर्तन के प्रति अधिक लचीला और टिकाऊ बनाते हैं।

1. सूखा और बाढ़ सहिष्णु किस्में:

जलवायु परिवर्तन के प्रभावों से निपटने के लिए सूखा सहिष्णु और बाढ़ सहिष्णु फसलों की किस्मों का विकास किया गया है। इन फसलों का उत्पादन कम पानी वाली परिस्थितियों में और बाढ़ प्रभावित क्षेत्रों में भी होता है, जिससे किसानों को स्थिर पैदावार प्राप्त करने में मदद मिलती है।

2. डेटा-आधारित कृषि:

आजकल जीपीएस, एआई, इंटरनेट ऑफ थिंग्स (IoT) और डेटा एनालिटिक्स जैसी आधुनिक तकनीकों का उपयोग कृषि में किया जा रहा है। ये तकनीकें संसाधनों के उपयोग में दक्षता बढ़ाती हैं और जलवायु परिवर्तन के प्रति लचीलापन प्रदान करती हैं। इससे किसानों को सटीक सिंचाई, कीट नियंत्रण और फसल प्रबंधन में मदद मिलती है।

3. नैनो-बायोचार और जैविक खेती:

नैनो-बायोचार का उपयोग मिट्टी के स्वास्थ्य को बढ़ाने, जल धारण क्षमता और कार्बन पृथक्करण

को बढ़ावा देने में किया जा रहा है। जैविक खेती में फसल चक्रीयकरण, कंपोस्टिंग और प्राकृतिक उर्वरकों का उपयोग किया जाता है, जिससे मिट्टी की उर्वरता में सुधार होता है और पर्यावरण पर कम दबाव पड़ता है।

4. जलवायु स्मार्ट सिंचाई:

जलवायु स्मार्ट सिंचाई प्रणालियाँ, जैसे ड्रिप सिंचाई, सेंसर और वास्तविक समय के डेटा का उपयोग कर पानी के उपयोग को अनुकूलित करती हैं, जिससे जलवायु परिवर्तन से प्रभावित क्षेत्रों में पानी की बचत और फसल उत्पादन में वृद्धि होती है।

5. संरक्षण कृषि:

संरक्षण कृषि में मिट्टी की उर्वरता और जैव विविधता को बढ़ाने के लिए न्यूनतम मिट्टी व्यवधान, स्थायी मिट्टी आवरण और फसल विविधीकरण पर जोर दिया जाता है। यह तरीका दीर्घकालिक कृषि स्थिरता सुनिश्चित करता है।

6. फसल मॉडलिंग और मौसम पूर्वानुमान:

फसल मॉडलिंग और उन्नत मौसम पूर्वानुमान तकनीकें किसानों को उपज और विकास की भविष्यवाणी करने में मदद करती हैं।

7. सटीक कृषि:

सटीक कृषि तकनीकों में रिमोट सेंसिंग, उपग्रह इमेजरी और डेटा विश्लेषण का उपयोग करके फसल स्वास्थ्य और मिट्टी की स्थिति का निगरानी की जाती है।

सरकारी पहलें और समर्थन

भारत सरकार ने किसानों को जलवायु परिवर्तन से निपटने और कृषि स्थिरता बढ़ाने के लिए कई योजनाएँ शुरू की हैं। प्रमुख कार्यक्रम हैं:

1. NICRA (राष्ट्रीय जलवायु-लचीला कृषि नवाचार):

यह कार्यक्रम ICAR द्वारा चलाया जाता है और इसका उद्देश्य जलवायु परिवर्तन के प्रभावों से निपटने के लिए कृषि पद्धतियों में नवाचार और शोध को बढ़ावा देना है।

2. NMSA (राष्ट्रीय सतत कृषि मिशन):

यह मिशन जलवायु स्मार्ट कृषि, जल संरक्षण, मृदा प्रबंधन और कीट प्रबंधन पर केंद्रित है, जो किसानों को जलवायु परिवर्तन के प्रभावों से बचने के लिए सक्षम बनाता है।

निष्कर्ष

जलवायु परिवर्तन के कारण कृषि पर कई तरह के प्रभाव पड़ रहे हैं, जैसे फसल विफलताएँ, मिट्टी का कटाव, पानी की कमी, और पशुधन की समस्याएँ। लेकिन इन चुनौतियों का समाधान करने के लिए कई प्रभावी उपाय और तकनीकें मौजूद हैं। जलवायु-लचीला कृषि, डेटा-संचालित तकनीकें, और सरकारी योजनाओं के माध्यम से किसानों को इन समस्याओं से निपटने के लिए समर्थन मिल रहा है। इन उपायों के जरिए हम कृषि क्षेत्र में जलवायु परिवर्तन के प्रभावों को कम करने और भविष्य में टिकाऊ खाद्य सुरक्षा सुनिश्चित करने में सक्षम होंगे।

Plant Growth Promoting Rhizobacteria: An Essential Tool for Sustainable Agriculture

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Plant growth-promoting rhizobacteria (PGPR) represent a promising solution for enhancing agricultural productivity in a sustainable manner. These naturally occurring soil bacteria can significantly improve plant growth, yield, and nutrient uptake through various mechanisms. Over the years, PGPRs have attracted increasing attention due to their potential to reduce the dependency on chemical fertilizers and pesticides, contributing to a more environmentally friendly and sustainable agriculture system (Saharan and Nehra, 2011; Katiyar et al., 2016).

What are PGPR?

PGPR are soil bacteria that reside in the rhizosphere, the region of soil surrounding plant roots, where they interact with plants through a variety of mechanisms that positively affect plant growth. These beneficial microbes can stimulate plant growth directly or indirectly by improving nutrient availability, enhancing disease resistance, producing plant hormones, and facilitating stress management (Figueiredo et al., 2010; Ashraf et al., 2013). Their role in agriculture extends beyond mere growth promotion, as they also contribute to biocontrol, environmental stress mitigation, and biofertilization.

PGPR are a diverse group of microorganisms, including nitrogen-fixing bacteria like *Rhizobium*, phosphate solubilizers, and those that produce plant growth regulators such as auxins, gibberellins, and cytokinins (Lugtenberg et al., 2009; Deshwal et al., 2013). These bacteria can either form a symbiotic relationship with the plant or act as free-living microorganisms in the soil. In the

case of nitrogen-fixing bacteria, such as *Rhizobium* and *Bradyrhizobium*, they form nodules on leguminous plants and convert atmospheric nitrogen into a form usable by plants, thus improving soil fertility (Datta et al., 2015).

Mechanisms of Action

PGPR enhance plant growth through various direct and indirect mechanisms. The most common direct mechanisms include nutrient acquisition, production of growth hormones, and protection against biotic stresses (Bhat et al., 2022; Katiyar et al., 2017). For instance, PGPR can produce siderophores, which are compounds that bind to iron and make it more available to plants (Saharan and Nehra, 2011). This is particularly important in soils where iron availability is limited. Similarly, some PGPR can solubilize phosphorus, an essential nutrient for plants, making it more bioavailable (Figueiredo et al., 2010).

Plant growth promotion is also facilitated by PGPR's ability to produce plant hormones. These hormones, especially auxins,

gibberellins, and cytokinins, regulate plant cell division, elongation, and differentiation, which lead to enhanced root development and biomass production (Patel and Minocheherhomji, 2018). Auxins, for example, stimulate root growth, allowing the plant to access more water and nutrients from the soil (Ashraf et al., 2013). The production of other phytohormones by PGPR can also aid in plant responses to various environmental conditions, further supporting their role in plant growth and productivity (Katiyar et al., 2017).

In terms of indirect mechanisms, PGPR play a key role in biocontrol by suppressing pathogens. Certain PGPR can inhibit the growth of harmful microorganisms in the rhizosphere by producing antibiotics, enzymes, or other antimicrobial compounds (Bhat et al., 2022). Additionally, PGPR can induce systemic resistance in plants, priming them to better defend against disease and pest attacks (Gopalakrishnan et al., 2014). This biocontrol activity reduces the need for chemical pesticides, thus decreasing the environmental impact of agriculture.

Another indirect benefit of PGPR is their role in alleviating abiotic stress, such as drought, salinity, and heavy metal toxicity. By enhancing plant tolerance to these stressors, PGPR contribute to maintaining crop productivity under challenging environmental conditions (Bhat et al., 2022).

PGPR as Biofertilizers and Biopesticides

One of the major advantages of PGPR is their potential as biofertilizers and biopesticides, making them an attractive alternative to chemical inputs. As biofertilizers, PGPR help to naturally enrich the soil with essential nutrients, reducing the need for synthetic

fertilizers, which can be harmful to the environment (Prathap and Ranjitha Kumari, 2015). Biofertilizers derived from PGPR can increase soil fertility by improving the availability of nitrogen, phosphorus, and potassium, as well as micronutrients. This is particularly important in the context of sustainable agriculture, where the use of chemical fertilizers is being discouraged due to their negative environmental impacts, such as groundwater contamination and soil degradation (Katiyar et al., 2016).

PGPR can also serve as biopesticides by suppressing pathogens and controlling pests. As biocontrol agents, PGPR can protect plants from a variety of pests and diseases, including fungi, bacteria, and nematodes. By reducing reliance on chemical pesticides, PGPR offer a more sustainable, eco-friendly approach to pest management (Prathap and Ranjitha Kumari, 2015; Gopalakrishnan et al., 2014).

Sustainability in Agriculture

The use of PGPR aligns with the growing trend toward sustainable agricultural practices. Sustainable agriculture focuses on reducing the environmental impact of farming while ensuring food security and maintaining ecosystem health. PGPR contribute to this goal by improving soil health, enhancing nutrient cycling, and reducing the need for chemical inputs. Their role in improving nutrient availability, stimulating plant growth, and enhancing resistance to pathogens supports the concept of integrated nutrient management, which is an essential component of sustainable agriculture (Reséndez et al., 2018).

PGPR-based biofertilizers and biopesticides also support the principles of organic farming, which emphasizes the use of natural inputs

and the preservation of soil biodiversity. By promoting plant growth without the use of harmful chemicals, PGPR help to maintain the balance of soil ecosystems and contribute to the long-term health of agricultural landscapes (Akhtar et al., 2012).

Challenges and Future Prospects

Despite the promising potential of PGPR in sustainable agriculture, there are several challenges to their widespread adoption. One of the primary obstacles is the variability in the effectiveness of PGPR, which can be influenced by factors such as soil type, climate conditions, and crop species. The mechanisms through which PGPR promote plant growth are complex and not fully understood, which makes it difficult to predict their performance under different agricultural conditions (Saharan and Nehra, 2011; Dhayalan and Sudalaimuthu, 2021).

Another challenge is the commercialization of PGPR products. While research on PGPR is extensive, there is a lack of standardized products that can be easily adopted by farmers. The development of effective PGPR-based formulations that are stable and easy to apply is essential for the broader acceptance of PGPR as a mainstream agricultural tool (Prathap and Ranjitha Kumari, 2015). Moreover, extensive field trials and long-term studies are needed to evaluate the effectiveness and safety of PGPR in various agricultural systems.

References

1. Saharan, B. S., and Nehra, V. (2011). Plant growth promoting rhizobacteria: A critical review. *Life Sciences and Medicine Research, 2011*(LSMR-21), 1-30. Available from: https://www.researchgate.net/publication/284340739_Plant_growth_promoting_rhizobacteria_a_critical_review

Despite these challenges, the future of PGPR in agriculture looks promising. Ongoing research is focused on identifying new strains of PGPR with enhanced properties, such as greater stress tolerance, improved nutrient solubilization, and more efficient pathogen suppression. Additionally, advances in biotechnology may allow for the genetic modification of PGPR to enhance their effectiveness and expand their range of applications in agriculture (Gopalakrishnan et al., 2014).

Conclusion

Plant growth-promoting rhizobacteria (PGPR) have emerged as a powerful tool for promoting sustainable agriculture. By enhancing plant growth, improving nutrient uptake, and providing protection against pests and diseases, PGPR offer a natural, environmentally friendly alternative to chemical fertilizers and pesticides. As biofertilizers and biopesticides, PGPR contribute to the long-term sustainability of agricultural systems by reducing the environmental impact of farming practices. While challenges remain in terms of their effectiveness and commercialization, ongoing research and technological advancements hold promise for the future development of PGPR-based solutions in agriculture.

As the agricultural sector continues to embrace sustainability, PGPR represent a key component of a more resilient, eco-friendly, and productive future for global food systems.

2. Katiyar, D., Hemantaranjan, A., and Singh, B. (2016). Plant growth promoting rhizobacteria—An efficient tool for agriculture promotion. *Advances in Plants and Agricultural Research*, 4(6), 426-434. <https://doi.org/10.15406/apar.2016.04.00163>
3. Figueiredo, M. D. V. B., Seldin, L., de Araujo, F. F., and Mariano, R. D. L. R. (2010). Plant growth promoting rhizobacteria: Fundamentals and applications. In D. Maheshwari (Ed.), *Plant growth and health promoting bacteria* (Microbiology Monographs, Vol. 18, pp. 21-44). Springer. https://doi.org/10.1007/978-3-642-13612-2_2
4. Patel, T. S., and Minocheherhomji, F. P. (2018). Plant growth promoting rhizobacteria: Blessing to agriculture. *International Journal of Pure and Applied Bioscience*, 6(2), 481-492. <https://doi.org/10.18782/2320-7051.6383>
5. Ashraf, M. A., Asif, M., Zaheer, A., Malik, A., Ali, Q., and Rasool, M. (2013). Plant growth promoting rhizobacteria and sustainable agriculture: A review. *African Journal of Microbiology Research*, 7(9), 704-709. <https://doi.org/10.5897/AJMR12.936>
6. Bhat, B. A., Tariq, L., Nissar, S., Islam, S. T., Islam, S. U., Mangral, Z., Ilyas, N., Sayyed, R. Z., Muthusamy, G., Kim, W., and Dar, T. U. H. (2022). The role of plant-associated rhizobacteria in plant growth, biocontrol, and abiotic stress management. *Journal of Applied Microbiology*, 133(5), 2717-2741. <https://doi.org/10.1111/jam.15796>
7. Lugtenberg, B., and Kamilova, F. D. (2009). Plant-growth-promoting rhizobacteria. *Annual Review of Microbiology*, 63, 541-556. <https://doi.org/10.1146/annurev.micro.62.081307.162918>
8. Deshwal, V. K., Singh, S. B., Kumar, P., and Chubey, A. (2013). Rhizobia unique plant growth promoting rhizobacteria: A review. *International Journal of Life Sciences*, 2, 74-86.
9. Datta, A., Singh, R.K., Kumar, S., and Kumar, S. (2015). An effective and beneficial plant growth promoting soil bacterium “Rhizobium”: A review. *Annals of Plant Sciences*, 4, 933-942.
10. Gopalakrishnan, S., Sathya, A., Rajendran, B., Kumar, R., Laxmipathi, C.L., and Krishnamurthy, L. (2014). Plant growth promoting rhizobia: Challenges and opportunities. *3 Biotech*, 5, 355-377. <https://doi.org/10.1007/s13205-014-0241-x>
11. Prathap, M., and Ranjitha Kumari, B.D. (2015). A critical review on plant growth promoting rhizobacteria. *Journal of Plant Pathology and Microbiology*, 6(4). <https://doi.org/10.4172/2157-7471.1000266>
12. Moreno Reséndez, A., García Mendoza, V., Reyes Carrillo, J. L., Vásquez Arroyo, J., and Cano Ríos, P. (2018). Rizobacterias promotoras del crecimiento vegetal: una alternativa de biofertilización para la agricultura sustentable [Plant growth promoting rhizobacteria: A biofertilization alternative for sustainable agriculture]. *Revista Colombiana de Biotecnología*, 20(1), 68-83. <https://doi.org/10.15446/rev.colomb.biote.v20n1.73707>
13. Akhtar, A., Hisamuddin, M. I., Robab, M., Abbasi, S., and Sharf, R. (2012). Plant growth promoting Rhizobacteria: An overview. *Journal of Natural Product and Plant Resources*, 2, 19-31.
14. Dhayalan, V., and Sudalaimuthu, K. (2021). Plant growth promoting rhizobacteria in promoting sustainable agriculture. *Global Journal of Environmental Science and Management*, 7, 401-418. <https://doi.org/10.22034/GJESM.2021.03.06>

Powering Farms Sustainably: The Role of Solar Energy and Biogas in Agriculture

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Traditional farming methods mainly depends on conventional resources of energy such as fossil fuels for powering farm machinery, irrigation systems, and other on farm based and off farm based equipments, and therefore leads to the emission of greenhouse gases. These emissions have a major impact on climate change, which further puts pressure on agricultural systems that are already vulnerable to the effects of climate change. Farmers are experiencing difficulties because of unpredictable weather patterns, including extreme droughts, floods, and heat waves. These events pose a direct threat to food production and world food security. The dependence on fossil fuels, along with the challenges introduced by the shifting climatic conditions, forms a vicious cycle that can affect agricultural productivity along with the environment in various forms. Use of renewable energy sources forms a feasible path toward climate-smart agriculture. By utilizing renewable energy technologies such as solar energy and biogas, farmers can greatly reduce their carbon footprint and can provide sustainable solutions to climate change.

Solar energy in Agriculture

1. Solar-Powered Irrigation Systems

The solar powered irrigation system is the most effective use of solar power in agriculture. The traditional irrigation systems run-on diesel pumps, and are among the major contributors to greenhouse gas emissions and air pollution. Solar irrigation systems offer an environmentally friendly solution by utilizing solar energy to power water pumps for irrigation. Generally, solar irrigation system consists of PV-Photovoltaic panels that convert sunlight into electricity, running water pumps out of wells, rivers, or reservoirs. Solar photovoltaic pumps are seen as viable option for irrigation challenges. They can lift water from various depths to power irrigation systems, particularly in far-off places or in arid areas where ground waters are not deep (Poonia et al., 2018). Solar energy holds significant promise for both cold storage and

photovoltaic systems (Pillai and Banerjee 2009). Due to its favorable geographical position, India can effectively harness solar power, positioning it as an excellent site for solar electricity generation. In India, the solar radiation averages between 4 KWh and 7 KWh daily (Thakur et al., 2022).

2. Solar irrigation systems have a number of advantages compared to traditional systems:

- i. **Reduction in Operating Expenses:** Solar-powered irrigation schemes helps to cut the expense of expensive diesel fuel, which could be a load for farmers, particularly in isolated areas where fuel may not be readily available.
- ii. **Energy Availability for Remote Communities:** Since there is autonomous and reliable access to energy from solar-powered irrigation, hence it ensures

scheduled forms of irrigation even in remote locations with high efficiency.

- iii. **Lower Greenhouse Gas Emissions:** Farmers can reduce their carbon footprint significantly by using solar power, which replaces fossil fuel-based pumps. Solar irrigation systems have zero direct emissions when in use.
 - iv. **Water Efficiency:** Solar-powered irrigation systems can be combined with improved irrigation methods like drip irrigation and micro-sprinklers, which reduce wastage of water and enhance the utilization of water efficiency, enabling farmers to respond to the challenges of unpredictable rain and climate change-driven water shortages.
- 3. Solar Energy for Other Farming Uses**
- i. **Solar Cold Storage and Refrigeration:** Cold stores powered by solar energy could assist farmers to store perishable items in order to prevent food wastage.
 - ii. **Solar-Powered Farming Equipment:** Solar sprayers, dusters, and dryers are beneficial for crop protection, drying fruits and vegetables, and help in post-harvest handling. They help in more precise and effective application of pesticides, in drying fruits and vegetables, and in improving food preservation.
 - iii. **Animal Feed Solar Cookers:** Farmers in semi-arid regions use solar cookers to prepare animal feeds in order to minimize fuel wood usage and improve the nutritional value of the feed. This technology not only conserves resources but also reduces environmental impacts.

Biogas in Agriculture

Biogas is among the renewable energy sources with immense potential for application in farms. Biogas is produced by anaerobic fermentation of organic waste such as animal dung, crop residues, food wastes,

and other organic biodegradable waste. The gaseous mixture containing methane (CH₄) in significant proportion can be utilized for cooking, supply of heat, electricity generation, or as a vehicle fuel. To increase biogas production and methane yield, a variety of techniques are employed, including the use of additives with organic matter as substrate, recycling of slurry, process optimization of operating parameters, reactor type changes etc. Biogas production is viewed as CO₂ neutral and, as such, it does not contribute to greenhouse gases in the atmosphere. The real problem arises when biogas is not properly captured or utilized. If biogas, which is primarily methane (CH₄), escapes into the atmosphere instead of being burned or properly harnessed, it can significantly contribute to GHG emissions (Minde et al., 2013). Methane is a far more potent greenhouse gas than CO₂—its global warming potential is 24 times greater than CO₂ over a 100-year period. Consequently, the main challenge lies in converting the energy from biogas combustion into heat and/or electricity. Another benefit of anaerobically processing organic waste is the mitigation of the negative effects associated with these wastes. In addition to producing electricity, biogas is sustainable, helps manage waste, cleans the environment, and ensures a steady supply of fuel. (Weiland, 2010).

Production of Biogas from Farm Waste

Agriculture produces a humongous amount of organic waste in the form of plant residues, manure, and plant waste. Farmers have the option of converting the waste into renewable energy while reducing pollution in the environment through the production of biogas.

- i. **Energy Independence:** The producers will be able to reduce dependency on grid electricity or fossil fuel by generating

energy from natural waste, most importantly needed in rural and off-grid areas where a proper means of energy supply is highly necessary.

- ii. **Waste Management:** Waste management on the farm becomes less expensive and environmentally friendly using biogas, prohibiting pollution through reducing the adverse effects of waste decomposition and open burning.
- iii. **Fertilizer Production:** It is the residual character after the process of biogas production that forms an organic fertilizer that is beneficial in improving the fertility of the soil and hence de-employs the chemical fertilizers and hence promotes sustainable agriculture.
- iv. **Climate Change Mitigation:** By producing biogas, methane emissions from organic waste are reduced, which would otherwise contribute to air pollution during decomposition. Since methane is a powerful greenhouse gas, using it for energy reduces its potential to cause global warming.

Renewable energy in agriculture sector and alignment with SDGs

Application of renewable energy in agricultural-related activities and other processes utilized in agriculture can assist in meeting several sustainable development goals (SDGs). It directly relates to SDG 7 (Affordable and Clean Energy) since it supports the utilization of clean, sustainable energies in agriculture in order to ensure that the exploitation of fossil fuel is minimized. It especially contributes to SDG 13 (Climate Action) by highlighting how renewable energy can be harnessed to reduce considerably the greenhouse gas emissions that contribute to climate change mitigation. By further promoting energy efficiency and sustainable resource utilization in agriculture,

it also supports SDG 12 (Responsible Consumption and Production) so that agricultural energy consumption is sustainable.

Role of renewable energy in combating impacts of climate change

Renewable technology is the foundation of combating climate change through greater energy efficiency and being clean fuels thus not emitting greenhouse gases. Solar panels are utilized to pump water for irrigation, supply light for agricultural activities, etc. without carbon-producing grid electricity, while biogas reduces methane emission by utilizing gases that otherwise go waste into the atmosphere from organic waste. The system not only curbs harmful emissions but also enhances sustainable agriculture by turning waste into a useful commodity. Renewable sources of energy strengthen the ability of agricultural systems to withstand the effects of climate change. Biogas as a local, decentralized source of power provides farmers with an assured supply of fuel even when climatic conditions are unfavorable. By providing farmers with cleaner and more assured power supplies, solar technologies and biogas provide long-term farm productivity in spite of the restrictions imposed by climate change.

Conclusion

Solar energy and biogas have great potential to be efficiently utilized as clean energy fuels, and their inclusion in farm operations can really make the difference in terms of reduction in carbon footprint and making on farm operations efficient in terms of both constant energy supply and minimizing the harm to environment. Solar powered irrigation pumps are one of the most potent use of solar energy for farm operations; however, there are also multiple ways through which solar energy can be utilized for various

farming procedures such as solar sprayers, dusters etc. Using biogas as fuel can serve as an efficient way of handling organic waste in

addition to providing clean energy. Therefore, it is imperative to use these clean energy sources for various farm operations.

References

1. Minde, G., Magdum, S., & Kalyanraman, V. (2013). Biogas as a sustainable alternative for current energy need of India. *Journal of Sustainable Energy & Environment*, 4, 121-132.
2. Pillai, I. R., & Banerjee, R. (2009). Renewable energy in India: Status and potential. *Energy*, 34(8), 970-980 <https://doi.org/10.1016/j.energy.2008.10.016>
3. Poonia, S., Jain, D., Santra, P., & Singh, A. K. (2018). Use of solar energy in agricultural production and processing. *Indian Farming*, 68(9).
4. Thakur, A. K., Singh, R., Gehlot, A., Kaviti, A. K., Aseer, R., Suraparaju, S. K., ... & Sikarwar, V. S. (2022). Advancements in solar technologies for sustainable development of agricultural sector in India: a comprehensive review on challenges and opportunities. *Environmental Science and Pollution Research*, 29(29), 43607-43634 <https://doi.org/10.1007/s11356-022-20133-0>
5. Weiland, P. (2010). Biogas production: current state and perspectives. *Applied microbiology and biotechnology*, 85, 849-860 <https://doi.org/10.1007/s00253-009-2246-7>

भारत में आनुवंशिक रूप से संशोधित (GM) सरसों की फसल

रवीनू धीमान

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भारत में अनुवांशित रूप से संशोधित सरसों की फसल के विषय में विस्तार से जानने से पहले हमें यह जानना अति आवश्यक है कि अनुवांशित रूप से संशोधित फसलें होती क्या हैं?

अनुवांशित रूप से संशोधित फसलें अनुवांशित रूप से संशोधित फसलें (Genetically Modified Crops या GM Crops) वे फसलें हैं जिन्हें जैव प्रौद्योगिकी तकनीकों का प्रयोग करके उनके आनुवंशिक सामग्री (DNA) में परिवर्तन किया गया है। इस कार्यप्रणाली में वांछित गुणों को प्राप्त करने के लिए एक जीव से जीन निकालकर उसे दूसरे जीव में डाला जाता है। इस तरह की फसलों के कई फायदे हैं, लेकिन साथ ही कुछ नुकसान भी हैं जो की इस प्रकार हैं-

आईए सबसे पहले हम नजर डालते हैं इन फसलों के फायदों पर:

उच्च उत्पादन: अनुवांशित रूप से संशोधित फसलें उच्च उपज देने के लिए डिजाइन की जाती हैं, जिससे कृषि उत्पादकता में वृद्धि होती है।

कीट प्रतिरोधी: इन फसलों को कीट प्रतिरोधी बनाया जाता है, जिससे कीटनाशकों के उपयोग की आवश्यकता कम हो जाती है।

रोग प्रतिरोधी: अनुवांशित रूप से संशोधित फसलें विभिन्न बीमारियों के प्रति प्रतिरोधी होती हैं, जिससे उनकी पैदावार अधिक होती है।

पोषण में सुधार: इन फसलों में पोषक तत्वों की मात्रा बढ़ाई जा सकती है, जैसे कि गोल्डन राइस में विटामिन A की मात्रा अधिक होती है।

पर्यावरणीय अनुकूलता: कुछ अनुवांशित रूप से संशोधित फसलें कठोर जलवायु और मिट्टी की स्थिति में भी उगाई जा सकती हैं, जिससे पर्यावरणीय परिस्थितियों के अनुरूप कृषि संभव हो पाती है।

अब इनके कुछ नुकसान पर ध्यान देते हैं:

स्वास्थ्य संबंधी चिंताएँ: इन फसलों के दीर्घकालिक स्वास्थ्य प्रभावों पर अभी भी अनुसंधान जारी है, और कुछ लोग मानते हैं कि इनके सेवन से स्वास्थ्य पर नकारात्मक प्रभाव हो सकते हैं।

जैव विविधता पर प्रभाव: इन फसलों के उपयोग से प्राकृतिक जैव विविधता पर प्रभाव पड़ सकता है, क्योंकि अनुवांशित रूप से संशोधित फसलें पारंपरिक फसलों को प्रतिस्थापित कर सकती हैं।

आर्थिक चिंता: इन फसलों के बीज महंगे होते हैं और इन पर पेटेंट अधिकार होते हैं, जिससे छोटे किसानों को वित्तीय दबाव का सामना करना पड़ सकता है।

पर्यावरणीय प्रभाव: कुछ अनुवांशित रूप से संशोधित फसलें पर्यावरण में अप्रत्याशित परिवर्तन ला सकती हैं, जैसे कि अन्य पौधों और कीटों पर असर डालना।

नैतिक और सामाजिक मुद्दे: कुछ लोग इन फसलों के उत्पादन तथा उपयोग को नैतिक दृष्टि से गलत मानते हैं और इसे प्राकृतिक संतुलन के विरुद्ध मानते हैं।

इन फसलों की खेती, कृषि में नए अवसर प्रदान करती है, लेकिन इनका सुरक्षित तथा संतुलित उपयोग ही भविष्य में कृषि तथा खाद्य सुरक्षा के लिए फायदेमंद साबित हो सकता है।

अनुवांशित रूप से संशोधित सरसों क्या है?

धारा सरसों हाइब्रिड-11 (DMH-11) को भारत में विकसित किया गया है। यह किस्म भारतीय सरसों 'वरुणा' और पूर्वी यूरोपीय किस्म 'अर्ली हीरा-2' के संकरण से उत्पन्न की गई है। धारा सरसों हाइब्रिड-11 (DMH-11) में दो विदेशी जीन ('बार्नेज' और 'बास्टार') शामिल हैं। ये जीन बैसिलस एमाइलोलिकेफेशियंस नामक मृदा जीवाणु से पृथक किए गए हैं। इन जीनों का समावेश उच्च उपज देने वाली व्यावसायिक सरसों संकर प्रजातियों के प्रजनन को सक्षम बनाता है। धारा सरसों हाइब्रिड-11 (DMH-11) को कृषि के लिए जेनेटिक इंजीनियरिंग मूल्यांकन समिति (GEAC) द्वारा अनुमोदित किया गया है। GEAC ने इस हाइब्रिड के विकास और उपयोग को मंजूरी दी है, जिससे यह सुनिश्चित किया जा सके कि यह कृषि क्षेत्र में सुरक्षित और प्रभावी है। इस अनुमोदन के साथ, DMH-11 को भारतीय कृषि में व्यापक पैमाने पर अपनाया जा सकता है। इसका उद्देश्य सरसों की पैदावार और गुणवत्ता को बढ़ाना है, जिससे किसानों को अधिक लाभ प्राप्त हो सके। इस किस्म को हर्बिसाइड टॉलरेंट (HT) सरसों की किस्म के रूप में वर्गीकृत किया गया है। इसे विशेष रूप से कुछ विशिष्ट हर्बिसाइड्स का सामना करने के लिए बनाया किया गया है, जो खरपतवार नियंत्रण में सहायता

करता है। इस तकनीक से किसान प्रभावी रूप से खरपतवारों को नियंत्रित कर सकते हैं, जिससे फसल की उपज बढ़ाई जा सकती है। हर्बिसाइड टॉलरेंट विशेषता के कारण, सरसों की यह किस्म न केवल उत्पादन को बढ़ावा देती है बल्कि कृषि प्रबंधन को भी सरल और अधिक कुशल बनाती है।

सरसों उत्पादन की महत्ता

तेल उत्पादन और आयात में सरसों का योगदान:

सत्र 2021-22 में भारत ने 116.5 लाख टन खाद्य तेलों का उत्पादन किया, इसके बावजूद 141.93 लाख टन खाद्य तेल आयात किया। यह महत्वपूर्ण अंतर भारत की बढ़ती मांग को दर्शाता है। अनुमान है कि सत्र 2025-26 तक खाद्य तेल की मांग 34 मिलियन टन तक पहुँच जाएगी। सरसों का इस पर महत्वपूर्ण योगदान है, क्योंकि यह भारत के कुल खाद्य तेल उत्पादन का 40% है।

अनुवांशित रूप से संशोधित सरसों की संभावित उपज वृद्धि:

अनुवांशित रूप से संशोधित सरसों, राष्ट्रीय मानक की तुलना में लगभग 28% अधिक उपज देती है और क्षेत्रीय बेंचमार्क को लगभग 37% तक पार करती है। यह विशिष्ट कृषि क्षेत्रों में बेहतर प्रदर्शन का संकेत देती है। DMH-11 जैसी इन सरसों की किस्मों में उपज को 3-3.5 टन प्रति हेक्टेयर तक बढ़ाने की क्षमता है।

बेहतर कृषि आदान दक्षता:

पारंपरिक किस्मों की तुलना में अनुवांशित रूप से संशोधित सरसों में जल, उर्वरक और कीटनाशकों की कम आवश्यकता के कारण संसाधन उपयोग को अनुकूलित कर सकती है। यह दक्षता संधारणीय कृषि प्रथाओं और पर्यावरणीय प्रभाव को कम करने के लिए महत्वपूर्ण है।

कीमत अस्थिरता में कमी:

अनुवांशित रूप से संशोधित सरसों के माध्यम से बढ़ा हुआ उत्पादन घरेलू बाजार में खाद्य तेल की कीमतों को स्थिर कर सकता है, जिससे उपभोक्ताओं को लाभ होगा और खाद्य सुरक्षा सुनिश्चित होगी।

अनुवांशित रूप से संशोधित (GM) सरसों का विकास भारतीय कृषि के लिए एक महत्वपूर्ण कदम हो सकता है। उचित नियमन और सतत निगरानी के माध्यम से अनुवांशित रूप से संशोधित सरसों का सुरक्षित और लाभकारी उपयोग सुनिश्चित किया जा सकता है। यह

संतुलन बनाए रखना महत्वपूर्ण है ताकि इसके फायदों का पूरा लाभ उठाया जा सके और संभावित जोखिमों को कम किया जा सके। सरसों की यह किस्म भारतीय कृषि के लिए एक नवीनतम और प्रभावशाली विकल्प हो सकता है, जो उत्पादन में वृद्धि और किसानों की आय में सुधार ला सकता है। इसके बावजूद, इसके दीर्घकालिक प्रभावों पर गहन अध्ययन और अनुसंधान आवश्यक है ताकि स्वास्थ्य, पर्यावरण, और आर्थिक चिंताओं को दूर किया जा सके।

बोगनविलिया : एक सजावटी पौधा

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बोगनविलिया एक रंगीन और सुंदर पुष्पवृक्ष है जो उष्णकटिबंधीय और उपोष्णकटिबंधीय क्षेत्रों में प्रमुख रूप से पाया जाता है। यह पौधा विशेष रूप से अपने चमकीले रंगों के लिए प्रसिद्ध है, जिसमें गुलाबी, बैंगनी, लाल, सफेद, और नारंगी रंग शामिल हैं। बोगनविलिया का नाम फ्रांसीसी नौसैनिक अधिकारी लुइस एंटोनी डी बोगनविले के नाम पर रखा गया है। इसे कागज का फूल भी कहा जाता है/ बोगनविलिया निकटागिनेसी परिवार से संबंधित है। यह दक्षिण अमेरिका का मूल निवासी है/ बोगनविलिया एक चढ़ने वाली बेल, झाड़ी, या छोटे पेड़ की तरह होती है/ यह पौधा मुख्य रूप से सजावट के रूप में उगाया जाता है और इसके सुंदर फूलों का उपयोग बगिया और गार्डन को सजाने के लिए किया जाता है/ बहुत ही कम देखभाल में बगीचे को सुंदर और रंगीन बनाने में यह पौधा उत्तम है/ इस पौधे की 18 प्रजातियाँ एवम 300 से ज्यादा किस्म के पौधे देखने को मिलते हैं जिनमें से कुछ प्रमुख प्रजातियाँ ये हैं: बोगनविलिया स्पेक्टेबिलिस, बोगनविलिया ग्लबरा, बोगनविलिया पेरुवियाना है / बोगनविलिया स्पेक्टेबिलिस को सबसे पहले 1860 में कोलकाता की कृषि उद्यान समाज में प्रस्तुत किया गया था। यह किसी भी प्रकार के मिट्टी और जलवायु में ज़िंदा रहते हैं/ इनमें ज्यादातर प्रजातियों के पौधे में नुकीले काँटे होते हैं/ इसमें करीब बारहों महीने फूल होते हैं/ बोगनविलिया के फूल देखने में ही सुन्दर नहीं हैं बल्कि इसके बहुत सारे एलोपैथिक एवं आयुर्वेदिक इलाज सामने आए हैं/ यह पौधा आयुर्वेद में खांसी, दमा, पेचिश, पेट या फेफड़ों के तकलीफ जैसी समस्याओं में उपयोग में लाया जाता है

वानस्पतिक वर्णन

यह प्रजाति 1 से 12 मीटर (3 से 39 फीट) ऊंची होती है, और अपने नुकीले कांटों से दूसरे पौधों पर चढ़ जाती है। जहां साल भर बारिश होती है वहां ये सदाबहार होते हैं या अगर सूखा मौसम हो तो ये पर्णपाती होते हैं। पत्तियाँ वैकल्पिक, सरल अंडाकार-नुकीली, 4-13 सेमी (1.6-5.1 इंच) लंबी और 2-6 सेमी (0.79-2.4 इंच) चौड़ी होती हैं। पौधे का वास्तविक फूल छोटा और आम तौर पर सफेद होता है, लेकिन तीन फूलों का प्रत्येक समूह तीन या छह सहपत्रों से घिरा होता है। बोगनविलिया अपने चमकीले, कागज जैसे ब्रैकेट्स

(ब्रैकेट्स वास्तव में पत्तियों का रूपांतरण है) के लिए जाना जाता है जो वास्तविक फूल को घेरते हैं। ब्रैकेट्स विभिन्न रंगों में आते, जैसे लाल, गुलाबी, बैंगनी, पीला, सफेद और यहां तक कि दो रंगों का मिश्रण भी। बोगनविलिया आमतौर पर झाड़ियों या लतायों के रूप में उगाए जाते हैं, और अपनी चढ़ने वाली आदतों के कारण दीवारों, बाड़ और आर्बरो को सुशोभित करने के लिए आदर्श होते हैं।

बोगनविलिया की कई किस्में हैं, जिनमें से कुछ सबसे लोकप्रिय हैं:

1. पर्पल वंडर
2. चित्रवती
3. अर्चना
4. वाजिद अली शाह
5. बेगम सिकंदर
6. ग्लोबोसा
7. स्पेक्टिबिलिस
8. ब्यूटी ऑफ़ बंगाल
9. फ्लेमिंगो
10. शुभ्रा

बोगनविलिया का उपयोग और लाभ

बोगनविलिया के कई उपयोग और लाभ हैं, जो इसे एक बहुमुखी पौधा बनाते हैं:

1. सजावटी

बोगनविलिया का उपयोग विभिन्न तरीकों से सजावट के लिये किया जाता है, जैसे की गमलिये पौधा, बॉसाई पौधा, दीवारों, बाड़, आर्बर, ग्रीटिंग कार्ड और लटकते टोकरी को ढंकना।

2. लैंडस्केपिंग

बोगनविलिया का उपयोग लैंडस्केपिंग में भी किया जाता है, जहां वे रंग और संरचना प्रदान करते हैं, विशेष रूप से उष्णकटिबंधीय और उपोष्णकटिबंधीय बागानों में। आजकल ये पौधा राष्ट्रीय राजमार्ग की सड़क वृक्षारोपण में काफी लोकप्रिय हो रहा है। इसके अलावा, इस पौधे का उपयोग होटल, पार्क, स्कूल और कॉलेज की लैंडस्केपिंग में भी हो रहा है।

3. औषधीय

बोगनविलिया के पत्तों और जड़ों का उपयोग कुछ पारंपरिक दवा प्रणालियों में विभिन्न स्वस्थों के इलाज के लिए किया जाता है।

4 प्रर्यावरण

बोगनविलिया प्रदूषण को अवशोषित करने और हवा की गुणवत्ता में सुधार करने में मदद कर सकते हैं।



मिट्टी

बोगनविलिया समृद्ध, अच्छी तरह से सुखी, अम्लीय (पीएच 5.5-6.0) मिट्टी में अच्छी तरह से बढ़ता है। यह मिट्टी में नहीं पनपता है जो लगातार गीली रहती है। उचित मिट्टी का पीएच आवश्यक है क्योंकि यह खनिज तत्वों की उपलब्धता को प्रभावित करता है। 6.0 से ऊपर की मिट्टी का पीएच सूक्ष्म पोषक तत्वों की कमी, विशेष रूप से लोहे की संभावना को बढ़ाता है। बोगनविलिया सूखा सहिष्णु, नमक सहिष्णु और हवा प्रतिरोधी है।

प्रजनन

बोगनविलिया पौधों को कटिंग से, ग्राउंड या एयर लेयरिंग और नवोदित करके प्रचारित किया जाता है। काटना: पेंसिल- 15-25 सेमी लंबाई की मोटी दृढ़ लकड़ी की पत्तेदार कटिंग सबसे अच्छी हैं। कटिंग डालने से पहले, उन्हें IBA (इंडोल ब्यूटिरिक एसिड) IAA (इंडोल एसिटिक एसिड) और NAA (नेफथलीन एसिटिक एसिड) जैसे विकास नियामकों के साथ घोल

या तालक में इलाज किया जा सकता है। "क्विक-डिप" विधि में उपयोग की जाने वाली सांद्रता आम तौर पर 1,000 और 3,000ppm के बीच होती है। बोगनविलिया को एक जोरदार बढ़ते रूटस्टॉक पर इनचिंग विधि द्वारा भी उठाया जा सकता है। जिन कल्टीवर को कटिंग से या लेयरिंग द्वारा नहीं उगाया जा सकता है, उन्हें "टी" या "शील्ड" नवोदित करके उठाया जाता है। आम तौर पर, 'डॉ आर.आर. पाल', एक जोरदार खेती, रूटस्टॉक के रूप में उपयोग की जाती है। 'पार्थ' भी एक अच्छा रूटस्टॉक है और कुछ स्थानों पर इसका उपयोग किया जाता है। सबसे अच्छा नवोत्तवित समय फरवरी से मार्च है। नए संकर या खेती प्राप्त करने के लिए पौधों को बीज से भी उठाया जाता है।



रोपण

उत्तरी भारत में रोपण का सबसे अच्छा समय जुलाई से सितंबर के दौरान है। सर्दियों में रोपण से बचना चाहिए क्योंकि मृत्यु दर अधिक होगी और पौधों की वृद्धि बहुत खराब होगी। पूर्वी भारत में, बारिश के दौरान रोपण किया जाता है। भारी वर्षा क्षेत्रों में रोपण बारिश से ठीक पहले या बाद में किया जा सकता है। लेकिन रोपण का सबसे अच्छा समय जून और अक्टूबर के बीच है। पौधों को प्राप्त करने के लिए लगभग 1 मीटर व्यास और 75 सेमी गहरे गड्ढे खोदे जाने चाहिए। रोपण के समय प्रत्येक

गड्ढे में लगभग 8-10 किलोग्राम अच्छी तरह से सड़ा हुआ गाय के गोबर को जोड़ा जाना चाहिए।

खाद और उर्वरक

खाद की मूल खुराक के बाद, बोगनविलिया को जून की छंटाई के बाद साल में एक बार 10-12 किलोग्राम गली सड़ी गोबर की खाद दी जाती है। इस समय, प्रत्येक पौधे पर 250 ग्राम हड्डी का भोजन भी लगाया जाना चाहिए। फूलों से पहले पखवाड़े के अंतराल पर ताजा गाय के गोबर या तेल केक को क्विंवित करके तरल खाद का उपयोग फायदेमंद पाया गया है।

सिंचाई

युवा पौधों या जो नए लगाए गए हैं उन्हें बार-बार पानी देने की आवश्यकता होती है। एक बार स्थापित होने के बाद, पौधों को बहुत कम या बिना पानी की आवश्यकता होती है। हालांकि, शुष्क इलाकों में, गर्मियों के दौरान प्रति माह एक भारी सिंचाई फायदेमंद होती है। बार-बार पानी देना हानिकारक है। फूलों के समय के दौरान पानी को प्रतिबंधित किया जाना चाहिए; अन्यथा, भारी पानी देने के परिणामस्वरूप ब्रैक्ट्स का बहाव होगा।

कटाई

बोगनविलिया को नियमित रूप से काटना चाहिए ताकि यह घनी और शाखाओं वाली हो। यह फूलों के उत्पादन को भी बढ़ावा देता है। विशेष रूप से मृत या सूखी शाखाओं को हटाना महत्वपूर्ण है। बोगनविलिया की कटाई के लिए तेज और साफ उपकरण जैसे छंटाई कैंची, आरा या कैंची का उपयोग करें। यह सुनिश्चित करता है कि कटाई साफ-सुथरी हो, जिससे पौधा जल्दी ठीक हो जाए और स्वस्थ रहे। बोगनविलिया को संकुचित और घना रखने के लिए इसे नियमित रूप से आकार देना

चाहिए। इसमें ऊंचाई, चौड़ाई, और दिशा को नियंत्रित करने के लिए हल्के कटौती की जाती है। जब बोगनविलिया की नई शाखाएं बढ़ने लगती हैं, तो उनकी टॉप (सिरे) को काटना (टिप प्रूनिंग) फायदेमंद होता है। इससे नई शाखाएं निकलती हैं, और पौधे पर फूलों की अधिकता होती है। से बोगनविलिया के पौधे की वृद्धि को नियंत्रित किया जा सकता है और इसकी सुंदरता को बनाए रखा जा सकता है। कटाई सही समय और सही तरीके से करना महत्वपूर्ण है ताकि पौधे को अधिकतम लाभ मिले।



कीट और रोग

बोगनविलिया एक कठोर पौधा है और कीट और रोग कोई समस्या नहीं है। अमेरिका में कुछ श्रमिकों द्वारा पत्ती की कुछ बीमारियों की सूचना मिली है, लेकिन ये भारत में गंभीर नहीं हैं। इसी तरह, कुछ श्रमिकों द्वारा यू.एस.ए. में कुछ पत्ती खाने वाले कैटरपिलर का उल्लेख

किया गया है, लेकिन ये भारत में कोई गंभीर परेशानी पैदा नहीं करते हैं।

निष्कर्ष

बोगनविलिया एक अद्भुत और रंग-बिरंगा पौधा है जो अपने आकर्षक फूलों और तेजी से बढ़ने की विशेषता के कारण बगीचों और बाहरी सजावट के लिए एक आदर्श विकल्प है। इसकी सुंदरता न केवल इसके रंगीन फूलों में बल्कि इसकी लताने वाली संरचना में भी छिपी होती है। यह पौधा बहुत कम देखभाल की आवश्यकता करता है और सूखा सहन करने में सक्षम होता है, जिससे यह किसी भी बगीचे के लिए एक आसान और प्रभावी विकल्प बनता है। बोगनविलिया का पौधा सुंदरता के साथ-साथ आयुर्वेदिक गुणों के कारण स्वास्थ्य के लिए भी लाभकारी हो सकता है। इसके विविध उपयोग, जैसे सजावट और प्राकृतिक बाड़ बनाने में इसकी भूमिका, इसे एक बहुउद्देश्यीय पौधा बनाते हैं। कुल मिलाकर, बोगनविलिया एक अद्वितीय और महत्वपूर्ण पौधा है जो न केवल पर्यावरण को सुंदर बनाता है, बल्कि मनुष्य के जीवन में भी रंग और स्वास्थ्य लेकर आता है।

Microorganisms in Biofloc Aquaculture System

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The term “microbes” is a general word that describes a numerous number of organisms. Examples of microbes are microscopic fungi, protozoa, algae, bacteria, and archaea. They live in water, soil, and in the air. In one line they are inseparable part of the environment. Likewise, microorganisms are an important member of any aquaculture system. Especially in Biofloc technology (BFT) they are the heart of the system.

Biofloc Technology and Microorganisms

In aquaculture system, the major item of expenditure is feed which is about 50% of total cost involved. Only 20- 30% of the feed used in aquaculture is being assimilated by culture animal and remaining accumulates as waste. The accumulated waste includes NH_4^+ -N and/or NO_2^- -N, which are toxic to the culture animals in a closed system. These toxic wastes can be effectively converted into useful nutrients by producing microorganisms by manipulation of carbon and nitrogen ratio (C/N) with biofloc technology.

The primary theme of biofloc technology is to convert nitrogenous waste of aquaculture system in to a microbial protein, a valuable nutrient for shrimp and fishes. The biofloc is generated by manipulation of C: N ratio. It serves multitude of function like provision of surplus microbial protein as feed, control toxic ammonia nitrogen and improve the immune system of aquatic animals.

BFT systems are a recent development in aquaculture that eliminate or minimize

water exchange while maintaining high stocking density. In such systems, addition of supplementary sources of carbon once C/N ratio reaches 15:1, induces the organisms that are already present in water to use the accumulated nitrogenous waste (in the form of unconsumed feed or excrement), which in turn accelerated their growth and leads to the formation of agglomerations known as flocs.

The exact make-up of the floc community in a BFT system depends on several factors e.g., the type of external carbon, environmental conditions such as salinity, light, oxygen levels, and solids load, the ratio of carbon to nitrogen (C/N ratio), and the cultivated species.

Main roles of Biofloc organisms (BFOs)

1. Maintaining water quality by consuming nitrogenous compounds
2. Providing a source of food for the cultivated species
3. Pathogen competition and create probiotic properties often by heterotrophic organisms (e.g. *Bacillus* spp.).

Greater diversity of BFOs can improve flocs' mineralization of waste, protein utilization, and pathogen control.

Common Microbes in biofloc system

- Photoautotrophic (e.g. Microalgae),
- Chemoautotrophic (e.g. Nitrifying bacteria)
- Heterotrophic organisms: Fungi, Ciliates, Protozoans, Zooplankton (e.g. rotifers, copepods, and nematodes)

Microalgae (phytoplankton)

- Eukaryotes (e.g. Diatoms, Chlorophytes, etc.)
- Prokaryote (e.g. Cyanobacteria)

These organisms play an important role in BFT system by using nitrogenous compounds to produce proteins and sugars, as well as providing oxygen when light is available. They are also consumed by zooplankton and thus transfer nutrients to higher trophic levels. Microalgae are also a good source of nutrients for aquatic organisms. For instance, eukaryotes (e.g. diatoms, *Chlorella* sp.) are good sources of essential amino acids and highly unsaturated fatty acids for shrimp. In biofloc systems, diatom inoculation helps to improve fish growth, FCR and also the fatty acid content in *L. vannamei* postlarvae.

Fungi

Microfungi can be considered as one of the most diverse eukaryotic organisms that play an important role in the decomposition of organic material. The presence of the filamentous microfungi in biofloc will strengthen and contribute to forming larger and stronger biofloc particles. Some species of microfungi such as *Aspergillus* sp. and *Penicillium* sp. were demonstrated to be bioflocculant producing micro-organisms with high flocculation activity. Interaction and association of microfungi and other micro-organism within the biofloc can stimulate the growth and survival of shrimp as well as

increase their resistance to disease. The existence of microfungi species such as *Aspergillus* sp. and *Penicillium* sp. in biofloc are perfect candidates in forming biofloc that can decrease water pollution towards circularity and sustainable aquaculture industry.

Zooplankton

- Various species of zooplankton (rotifers, protozoans, crustaceans, and nematodes) naturally occur in BFT systems and function in nutrient recycling, maintenance of water quality, and nutrition of the cultivated species.
- Consumption of BFOs by the cultivated species can improve growth rate, decrease FCR, and provide a more balanced diet. Rotifers can contain 54–60 % raw protein; the same figure for cladocerans and copepods is 50–68 % and 70–71 %, respectively. The lipid content of these three groups is respectively 3.9–13.2 %, 1–2.9 %, and up to 2.6 %.
- Nematodes can also be good sources of nutrients; nematode dry matter is 40 % protein and 20 % fat, with the remaining 40 % being composed of nitrogen-free extract and other macronutrients.
- Ciliates feed on algae, bacteria, and fungi and are in turn consumed by metazoans. Ciliates are a rich source of free amino acids, and similar to flagellates, can provide other organisms with polyunsaturated fatty acids and sterols (polyunsaturated fatty acids) for the shrimp.
- Protozoa are an important component of BFOs as they can colonize organic particles and consume bacteria

Bacteria

The last few years have witnessed extensive research on the microbial composition of biofloc. Studies suggested that biofloc is mostly dominated by Gram negative bacteria. Reports say that most of the screened bacteria belong to Proteobacteria phylum followed by Bacteroides and Cyanobacteria. The member of phylum proteobacteria is widely dispersed in the marine environment and plays an important role in the process of nutrient cycling and the mineralization of organic compounds. Among *Proteobacteria*, *Vibrio* group is the most predominant one. Studies also indicated that biofloc system had increased level of *Bacillus* and *Lactobacillus* bacterium which have probiotics properties.

Bacteria need simple nitrogen like ammonium ion and carbon source such as sugar, starch, cellulose etc. to run its cellular machinery. This makes it amenable for utilization of toxic ammonia nitrogen from intensive aquaculture system. Another characteristic feature of bacterial growth is its faster growth rate, as it almost doubles its number within 30 minutes. The bacterial efficiency of nutrient conversion is as high as 50%. Therefore, in nutshell bacteria with its fast multiplication rate are highly efficient in converting toxic product of the aquatic system into the useful, highly nutritious, much demanded microbial protein. Though intensive aeration is required in biofloc system to meet enhanced oxygen demand for microbial growth and fish. It also assists to keep biofloc in suspension.

Microbial role in biofloc system

Bioremediation of toxic ammonia

The biofloc system maintains adequate water quality especially toxic nitrogen metabolites. At higher C: N ratio, bacteria immobilize

toxic ammonia into microbial protein within few hours as compared to slow conventional nitrification process which takes a month to get established. There are three predominant pathways for ammonia-nitrogen assimilation function in aquaculture systems. This includes photoautotrophic, chemo-autotrophic and heterotrophic system. The photoautotrophic system is mediated by algae and diatoms and mostly works at nitrate level, the last and the least toxic metabolite of nitrogen cycle. However, the other two systems (chemo-autotrophic and heterotrophic) system is mediated by bacteria and start functioning from ammonia level, the most important toxic metabolite in shrimp culture. The chemo-autotrophic microbial system is managed by *Nitrosomonas* and *Nitrobacter* and the end product is nitrate. In contrast, heterotrophic microbial system is not only reducing ammonia level but also convert it into single cell microbial protein called biofloc.

Biocontrol agent

Numerous studies have reported that shrimps/fish are healthiest and grow best in aquaculture systems that have high levels of algae, bacteria and other natural microbiota. Probiotics are viable microbial cells and have beneficial effect on health of shrimp by stimulation of immune system and microbial equilibrium in intestine, and by inhibition of pathogenic microbes. Microbes store poly- β -hydroxy butyrate (PHB) as a stored product of carbon and energy. Its synthesis is stimulated in the condition of limited nitrogen supply and with excess carbon supplementation. Condition available in biofloc system thus enhances its production. The PHB particles offer preventive and curative protection in *Artemia nauplii* against luminescent

pathogenic *Vibrio campbelli*. This indicates that biofloc can serve as a novel strategy for disease management on a long-term basis.

Healthy supplementary food

The protein content of bacteria is almost 60%. Therefore, its consumption becomes an alternate source of protein for aquatic animals like shrimp.

Probiotics and immunostimulant

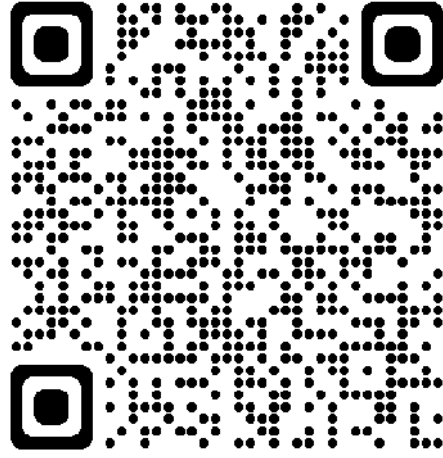
Biofloc is a microbial consortium, which has a large number of bacteria, that could play a powerful role in digestive enzyme secretion and as immunostimulant. Biofloc system improves the load of *Bacillus* and *Lactobacillus* bacterium which is expected to play a role in probiotics and immunostimulant effect.

Conclusion

BFT aquaculture is considered as a step towards sustainable aquaculture by increasing production, supplementing the animals' diets, contributing to bioremediation and biodegradation, to maintain water quality and reducing the need for water exchange. The proper BFT management will boost probiotic BFOs and limit harmful bacteria in BFT. It helps to improve the digestion and reduce the Food Conversion Ratio. Thus, use of biofloc technology serves multiple aspects in aquaculture, viz. higher growth rate, less water usage, reduced disease incidences and increased survival rate. As microorganisms are one of the most important components in a biofloc system, it is necessary to carry out more studies focused on identification of microbes that can enhance the productivity of biofloc systems.

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