

# National Seminar on

## Integrating Biochar Production, Carbon Sequestration and Carbon Trading for a Carbon Neutral Farming

### PROCEEDINGS



5-6 December, 2024

University of Agricultural Sciences, Dharwad



*Organized by*  
Dr. S. V. Patil Foundation and  
University of Agricultural Sciences, Dharwad







*National Seminar*  
*on*  
**Integrating Biochar Production,  
Carbon Sequestration and  
Carbon Trading for a Carbon Neutral Farming**

**PROCEEDINGS**

*Organized on*  
*5-6 December 2024*  
*at*  
*University of Agricultural Sciences, Dharwad*



*Organized by*  
**Dr. S. V. Patil Foundation and  
University of Agricultural Sciences, Dharwad**





## **Proceedings of National Seminar on Integrating Biochar Production, Carbon Sequestration and Carbon Trading for a Carbon Neutral Farming**

- Year of publication** : February, 2026
- Pages** : IV + 42
- Copies** : 100
- Copy right** : University of Agricultural Sciences, Dharwad – 580 005
- Editorial Committee** : Dr. B. N. Aravinda Kumar  
Dr. H. B. Babalad  
Dr. V. S. Korikanthi math  
Dr. V. C. Patil  
Dr. U. K. Shanwad  
Dr. S. Rajkumar  
Ms. P. K. Gayathri
- Organizing Secretary** : Dr. B. N. Aravinda Kumar
- Co-Organizing Secretaries** : Dr. U. K. Shanwad  
Dr. V. S. Kubsad  
Dr. S. Rajkumara  
Dr. V. B. Kuligod
- Publisher** : Dr. S. V. Patil Foundation  
University of Agricultural Sciences, Dharwad, Karnataka
- Publication Sponsored by** : National Bank for Agriculture and Rural Development  
(NABARD), Bengaluru
- Designing and  
Typesetting** : **DTP Unit**  
Publication Centre  
Directorate of Education, UAS, Dharwad

**Citation** : Dr. B. N. Aravinda Kumar, Dr. H. B. Babalad, Dr. V. S. Korikanthimath, Dr. V. C. Patil, Dr. U. K. Shanwad, Dr. S. Rajkumar and Ms. P. K. Gayathri. Integrating Biochar Production, Carbon Sequestration and Carbon Trading for a Carbon Neutral Farming. Proceedings of National Seminar. Dr. S. V. Patil Foundation for Research, Training and Farmers Welfare, UAS, Dharwad-580 005 (INDIA), pp46.



**Dr. P. L. Patil**  
Vice-Chancellor

## University of Agricultural Sciences Dharwad



### Message

It gives me immense pleasure to present the proceedings and recommendations of the First National Seminar on “*Integrating Biochar Production, Carbon Sequestration and Carbon Trading for a Carbon Neutral Farming*”, organized on 5–6 December 2024 at the University of Agricultural Sciences, Dharwad, in collaboration with the Dr. S. V. Patil Foundation.

The seminar emerged as a timely and visionary initiative in response to the pressing challenges of soil degradation, declining soil organic carbon, climate variability and the urgent need for sustainable agricultural transformation. The deliberations emphasized that biochar, often referred to as “black gold,” holds tremendous promise in enhancing soil health, improving nutrient use efficiency, sequestering carbon and creating new opportunities through carbon credit mechanisms.

Distinguished scientists, policymakers, entrepreneurs and industry experts deliberated on environmental sustainability, innovative applications of biochar, carbon market mechanisms and regenerative farming systems. The discussions highlighted the importance of integrating biochar into mainstream agricultural practices through scientific validation, standardization, policy support and farmer-centric models. Special emphasis was laid on interdisciplinary research, sustainable biomass utilization, optimization of pyrolysis technologies and integration of biochar with organic and co-composting systems.

The seminar strongly recommended the development of a National Biochar Policy with clear quality standards and testing protocols, incorporation of biochar into major government schemes such as Soil Health Card and Sustainable Agriculture Mission, and provision of financial incentives including carbon credits to farmers. It was also proposed to establish a “Biochar Society of India” to coordinate research, documentation of traditional practices and dissemination of best practices across the country.

The deliberations further recognized the critical role of smallholder farmers in climate change mitigation and emphasized capacity building, awareness creation and establishment of testing and certification facilities to ensure safe and effective use of biochar. Monitoring of long-term environmental impacts and exploration of non-agricultural applications such as water treatment and waste management were also identified as future thrust areas.

I commend the Dr. S. V. Patil Foundation, the organizing committee and all participating institutions for their dedicated efforts in conducting this meaningful national seminar. The recommendations emerging from this seminar provide a clear roadmap for advancing carbon-neutral farming systems and positioning India as a global leader in sustainable and climate-resilient agriculture.

Let us collectively translate these deliberations into action through collaborative research, policy advocacy and farmer-oriented implementation, thereby strengthening soil health, enhancing farmer incomes

  
**P. L. Patil**  
(Vice Chancellor)



## Organizing Institutions

### University of Agricultural Sciences (UAS), Dharwad

**The University of Agricultural Sciences (UAS), Dharwad**, established on 1st October 1986, is a premier agricultural university serving the farming community of twelve districts of northern Karnataka. With a strong mandate of education, research and extension, the University functions through five constituent colleges, twenty-seven research stations, six Agricultural Extension Education Centres, six Krishi Vigyan Kendras and an Agricultural Technology Information Centre (ATIC). Over nearly four decades of dedicated service, UAS Dharwad has earned national recognition as the “Farmers' University” for its farmer-centric, demand-driven and technology-oriented approach. The University has been adjudged as the Best Agricultural University in the country and has been conferred twice with the Sardar Patel Outstanding ICAR Institution Award. It has also received several prestigious national awards and is accredited with an 'A' Grade by the Indian Council of Agricultural Research (ICAR).

## Dr. S.V.Patil Foundation

Dr. S. V. Patil Foundation was established under the Charitable and Religious Trust Act 1921 on 20.06.2022 at University of Agricultural Sciences, Dharwad. The Dr. S. V. Patil Foundation was established to honour Dr. S. V. Patil, a visionary agricultural scientist and institution builder who made outstanding contributions to agricultural education and farmer welfare in northern Karnataka. With support from the University of Agricultural Sciences, Dharwad and the Government of Karnataka, the foundation oversees the “Dr. S. V. Patil Chair” and brings together experts to promote research, training, entrepreneurship and initiatives that strengthen farming communities. Through its programmes and outreach, the foundation continues Dr. Patil's lifelong mission of advancing agriculture and improving the livelihoods of farmers. The foundation works to promote agricultural research, training and farmer's welfare, while creating awareness among farmers, students and the public. It supports education and innovation by conducting research activities, offering scholarships, organizing seminars and publishing scientific and educational materials. It also collaborates with similar institutions, manages property for its mission and provides financial assistance to deserving



**National Seminar on  
Integrating Biochar Production, Carbon Sequestration and Carbon Trading for Carbon Neutral Farming  
December 5–6, 2024**

**COMMITTEES**

**I. Steering Committee**

Sl. No.	Name & Designation	Position
1	Dr. P. L. Patil, Vice -Chancellor, UAS, Dharwad	Chairman
2	Dr. V. R. Kiresur, Director of Education, UAS, Dharwad	Co-Chairman
3	Smt. Jayalakshmi Raikod, KAS, Registrar, UAS, Dharwad	Member
4	Dr. B. D. Biradar, Director of Research, UAS, Dharwad	Member
5	Dr. B. D. Biradar, Director of Extension, UAS, Dharwad	Member
6	Dr. R. Basavarajappa, Dean (PGS), UAS, Dharwad	Member
7	Dr. P. U. Krishnaraj, University Librarian, UAS, Dharwad	Member
8	Dr. Sarojini Karakkanavar, Dean (Students Welfare), UAS, Dharwad	Member
9	Dr. I. K. Kalappanavar, Dean (Agri), College of Agriculture, Dharwad	Member
10	Dr. A. Bheemappa, Dean (Agri), College of Agriculture, Vijayapur	Member
11	Dr. J. S. Hilli, Dean (Agri), College of Agriculture, Hanumanamatti	Member
12	Dr. R. Vasudev, Dean (CoF), College of Forestry, Sirsi	Member
13	Dr. P. U. Krishnaraj, Dean (CS), College of Community Science, Dharwad	Member
14	Shri S. M. Honnalli, Comptroller, UAS, Dharwad	Member
15	Dr. M. V. Manjunatha, Administrative Officer, UAS, Dharwad	Member
16	Shri B. D. Chavan, Estate Officer, UAS, Dharwad	Member
17	Dr. P. S. Matiwade, ADR (HQ), UAS, Dharwad	Member
18	Dr. S. A. Gaddanakeri, ADE (HQ), UAS, Dharwad	Member
19	Dr. Ravi Hunje, Special Officer (Seeds), UAS, Dharwad	Member
20	Dr. H. B. Babalad, Chair Professor & Secretary, Dr. SVPF, UAS, Dharwad	Member
21	Dr. U. K. Hulihalli, Professor (Retd.) & Treasurer, Dr. SVPF, UAS, Dharwad	Member
22	Dr. B. N. Aravind Kumar, Professor of Agronomy, UAS, Dharwad	Convener

**II. Programme Committee**

Sl. No.	Name & Designation	Position
1	Dr. B. N. Aravinda Kumar, Professor of Agronomy, UAS, Dharwad	Chairman
2	Dr. Rajkumara S., Professor, Dept. of Agronomy, AC, Dharwad	Co-Chairman
3	Dr. Gurudatt Hegde, Principal Scientist, AICRP (Wheat)	Member
4	Dr. S. K. Deshpande, Professor, Dept. of GPB, AC, Dharwad	Member
5	Dr. C. P. Chandrashekhar, Professor, Dept. of Agronomy, AC, Dharwad	Member
6	Dr. Surekha Sankanagoudar, Program Co-ordinator, KCRS-FM, UASD	Member
7	Dr. B. S. Yenagi, Associate Prof. (Agron.), AICRP on Oilseeds, UASD	Member
8	Dr. Sunilkumar Nooli, Scientist (Agron.), ARS, Hukkeri	Member
9	Dr. U. K. Shanwad, Scientist (Agron.), ARS (Cotton), Dharwad Farm	Member
10	Dr. Ravikumar Hosamani, Asst. Prof. (Ent.), IABT, AC, Dharwad	Member
11	Dr. Basavaraj Bagewadi, Asst. Professor, IABT, AC, Dharwad	Member
12	Dr. Sumitra B. S., Research Associate, Dr. SVPF, UAS, Dharwad	Member



### III. Event Arrangement and Stage Decoration Committee

Sl. No.	Name & Designation	Position
1	Dr. V. S. Kubsad, Prof. & Head, Dept. of Agronomy, AC, Dharwad	Chairman
2	Dr. G. O. Manjunath, Prof. & Head, Dept. of Horticulture, AC, Dharwad	Co-Chairman
3	Dr. R. V. Hegde, Professor of Horticulture, AC, Dharwad	Member
4	Dr. P. S. Pattar, Professor, Dept. of Agronomy, AC, Dharwad	Member
5	Dr. M. S. Biradar, Professor, Dept. of Horticulture, UAS, Dharwad	Member
6	Dr. Sunita Johri, Asst. Prof., AICRP Forestry, MARS, Dharwad	Member
7	Dr. Channakeshava, Asst. Prof., AICRP on Soybean, Dharwad	Member
8	Dr. Airadev Angadi, SMS (Hort.), KVK, Dharwad	Member
9	Shri Nannu Saab Noolkar, Electrician, Estate Office, UAS, Dharwad	Member
10	Shri Davalsaab Walikar, Field Asst., Dept. of Agronomy, AC, Dharwad	Member
11	Shri Yusuf Nadaf, Field Asst., Dept. of Horticulture, AC, Dharwad	Member

### IV. Registration Committee

Sl. No.	Name & Designation	Position
1	Dr. Ganajaxi Math, Professor, Dept. of Agronomy, AC, Dharwad	Chairman
2	Dr. Sudha T., Professor, O/o Dean (PGS), UAS, Dharwad	Co-Chairman
3	Dr. P. Ashoka, Professor & Head, Dept. of Agronomy, AC, H'Matti	Member
4	Dr. H. G. Ramya, Asst. Professor, C.C.Sc., Dharwad	Member
5	Dr. Priya P., Asst. Professor, Dept. of Agronomy, AC, H'Matti	Member
6	Dr. Gurupad Ballol, Asst. Prof., AICRP Mullarp, Dharwad	Member
7	Dr. Rajkumar G. R., Assoc. Professor of Soil Science, AC, Dharwad	Member
8	Dr. Sumesh K. G., Asst. Prof. of Agrometeorology, Dharwad	Member

### V. Transportation Committee

Sl. No.	Name & Designation	Position
1	Er. H. F. Gonageri, Asst. Engineer, Estate Office, UAS, Dharwad	Chairman
2	Dr. D. N. Kambreakar, Sr. Scientist & Head, KVK, Dharwad	Co-Chairman
3	Dr. Bandiwaddar T. T., Asst. Prof., AICRP on Sorghum, Dharwad	Member
4	Dr. Shivashankarmurthy, Pr. Scientist & Head, KVK, Indi	Member
5	Dr. Prasanna Kumar B. H., Scientist (Agron.), AICRP on MuLLarp	Member
6	Shri Y. N. Shinganalli, Sr. Asst., Dean (Agri) office, AC, Dharwad	Member



## VI. Accommodation Committee

Sl. No.	Name & Designation	Position
1	Er. B. D. Chavan, Estate Officer, UAS, Dharwad	Chairman
2	Shri H. F. Gonageri, Asst. Engineer, Estate Office, UASD	Co-Chairman
3	Dr. Rajeev B. Negalur, Professor, ARS, Mundgod	Member
4	Dr. R. M. Kachapur, Assoc. Prof., AICRP on Maize, Dharwad	Member
5	Dr. A. D. Naik, Professor, Dept. of ABM, AC, Dharwad	Member
6	Dr. M. B. Doddmani, Professor, Dept. of Crop Physiology, AC, Dharwad	Member

## VII. Publication Committee

Sl. No.	Name & Designation	Position
1	Dr. Ramesh Bhat, Editor, Publication Centre, UAS, Dharwad	Chairman
2	Dr. S. R. Salakanikoppa, Pr. Scientist & Head, AICRP (Maize), UASD	Co-Chairman
3	Dr. R. H. Patil, Assoc. Professor, Dept. of Agronomy, AC, Dharwad	Member
4	Dr. Spurthi Nayak, Asst. Prof., IABT, AC, Dharwad	Member
5	Dr. Uday G.Reddy, Asst. Prof. (GPB), AICRP on Wheat, Dharwad	Member
6	Dr. G. K. Naidu, Asst. Prof., AICRP on Soybean, UAS, Dharwad	Member

## VIII. Publicity Committee

Sl. No.	Name & Designation	Position
1	Dr. S. A. Gaddanakeri, ADE (HQ), UAS, Dharwad	Chairman
2	Dr. S. V. Halakatti, Professor of Agril. Extension, AC, Dharwad	Co-Chairman
3	Dr. S. N. Jadhav, Professor, DE Office, UAS, Dharwad	Member
4	Dr. Mouneshwari Kammar, Professor, DE Office, UAS, Dharwad	Member
5	Dr. Praveen Goroji, Sr. Tech. Asst., KVK, Dharwad	Member
6	Dr. Santosh Onte, SMS (Agron.), KVK, Dharwad	Member
7	Shri Arjun Goudar, Lab. Asst., AV lab, DE office, UAS, Dharwad	Member

## IX. Food Committee

Sl. No.	Name & Designation	Position
1	Dr. P. S. Matiwade, ADR (HQ), UAS, Dharwad	Chairman
2	Dr. P. S. Tippannavar, Professor (Entomology), MARS, Dharwad	Co-Chairman
3	Dr. K. D. Lamani, Sr. Scientist, AICRP on Wheat, MARS, Dharwad	Member
4	Dr. G. Somanagouda, Pr. Scientist (Agron) & Head, AICRP (Soybean)	Member
5	Dr. Nagabhushan K. Nayidu, Asst. Prof., Dept. of GPB, AC, Dharwad	Member
6	Dr. Sangshetty, Agronomist, ARS, Annigeri	Member
7	Mr. Suresh Ghatanatti, Tech. Officer, AICRP on Wheat, Dharwad	Member
8	Dr. Kumar C. J., Tech. Officer, Seed Unit, Dharwad	Member
9	Dr. Dinesh H. B., Tech. Officer, Seed Unit, Dharwad	Member



## X. Oral Presentation Committee

Sl. No.	Name & Designation	Position
1	Dr. S. S. Hallikeri, Professor, Dept. of Agronomy, AC, Dharwad	Chairman
2	Dr. M. P. Potdar, Chief Scientist, AICRP (DLA), Vijayapur	Co-Chairman
3	Dr. Virupaksha Prabhu, Professor (Pathology), AC, Dharwad	Member
4	Dr. Prashanthi S. K., Professor (Pathology), AC, Dharwad	Member
5	Dr. Geeta Goudar, Assoc. Prof. (Microbiology), Dharwad	Member

## XI. Poster Presentation Committee

Sl. No.	Name & Designation	Position
1	Dr. J. A. Hosmath, Prof. & Head, Dept. of Agronomy, AC, Dharwad	Chairman
2	Dr. B. T. Nadagouda, Prof. & Head, Dept. of Agronomy, AC, Vijayapur	Co-Chairman
3	Dr. Sumangala Bhat, Prof. & Head (GPB), AC, Dharwad	Member
4	Dr. S. A. Biradar, Professor of Agronomy, AICRP (DLA), Vijayapur	Member
5	Dr. N. M. Kerur, Professor of ABM, Directorate of Edn., UAS, Dharwad	Member
6	Dr. S. B. Nandar, Asst. Prof. & Head, Dept. of Phy. Edn., AC, Dharwad	Member

## XII. Entertainment Committee

Sl. No.	Name & Designation	Position
1	Dr. V. K. Deshpande, Prof. & Head, Dept. of SS&T, AC, Dharwad	Chairman
2	Dr. B. R. Jagadish, Professor, Dept. of Soil Science, AC, Dharwad	Co-Chairman
3	Dr. Renuka Salunke, Prof. & Head, FRM, CSc, Dharwad	Member
4	Dr. D. H. Mitrannavar, Asst. Prof., Dept. of Agribusiness Management, ACD	Member
5	Dr. Netra P., Asst. Prof. (Crop Physiology), AC, Dharwad	Member

## XIII. Finance Committee

Sl. No.	Name & Designation	Position
1	Dr. U. K. Hulihalli, Professor (Retd.) & Treasurer, Dr. SVPF, UAS, Dharwad	Chairman
2	Dr. B. N. Aravinda Kumar, Professor of Agronomy, UAS, Dharwad	Co-Chairman
3	Shri M. V. Nagaraj, Personal Secretary, Comptroller's Office, UASD	Member
4	Shri Daval Valikar, Field Asst., Dept. of Agronomy, AC, Dharwad	Member



**UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD**

**National Seminar**

**on**

**Integrating Biochar Production, Carbon Sequestration and  
Carbon Trading for Carbon Neutral Farming**

**(5<sup>th</sup> and 6<sup>th</sup> December, 2024)**

**Organized by**

**Dr. S. V. Patil Chair for Research and Training for Farmers Welfare and  
University of Agricultural Sciences, Dharwad, Karnataka, India**

**Programme Schedule**

<b>Registration</b>	<b>05-12-2024</b>	<b>09.00-11.30</b>	<b>Community Science Auditorium</b>
	<b>06-12-2024</b>	<b>09.00-10.30</b>	<b>V C Conference Hall, UAS Dharwad</b>
<b>Day-1 : 05-12-2024 (Venue: Community Science Auditorium, UAS Dharwad)</b>			
<b>10.00-12.00</b>	<b>Inaugural Session</b>		
<b>Key Note Address</b>	<b>Dr.P. Chandrashekhar Rao</b> Former Dean (PGS), PJTSAU Telengana		
<b>12.00-12.30</b>	High Tea		
<b>12.30-14.00</b>	<b>Theme 1. "Biochar for Environmental Sustainability and Climate Action</b> ( Policies, Practices and Commercial Perspectives) <b>Chairman:</b> Dr.P. Chandrashekhar Rao <b>Co- Chairman:</b> Dr. B.D.Biradar, Director of Research, UAS, Dharwad <b>Rapporteurs:</b> Dr. M. P. Potdar, Chief Scientist (DLA) Dr. Shivamurthy D. Agronomist, ARS, Nipani		
<b>Time</b>	<b>Speakers</b>	<b>Topic</b>	
<b>12.30-12.50</b>	<b>Mr. R. K. Mehta</b> President Hyderabad Biochar Society	Biochar for Sustainable Development	
<b>12.50-13.05</b>	<b>Dr. N. Sai Bhaskar Reddy</b> Hyderabad	National Biochar Policy and Standards for India	
<b>13.05-13.20</b>	<b>Dr. Madhukar Potdar,</b> Founder Maha-Dragon Association, Pune	On farm production & Characterization of Biochar from various crop wastes in the Kutch desert of Gujarat.	
<b>13.20-13.35</b>	<b>Mr. Kul Rora,</b> Circonomy Pvt. Ltd. Singapore	Empowering Smallholder Farmers: From agri - waste to Carbon Credits	
<b>13.35-13.50</b>	<b>Mr. Anil Chouk,</b> CEO Sanjeevini Agro, Nagpur	Designing, Supply and Servicing of Customized Pyrolisers for Biochar Production	
<b>13.50-14.05</b>	<b>Mr. S. K. Bhat,</b> Nullwaste Industries, Bengaluru	Biochar, Bio-oil and Biogas: A Commercial Perspective of Biomass Pyrolysis	
<b>14.05-15.00</b>	<b>Lunch Break</b>		



<b>15.30-17.00</b>	<b>Theme 2. Innovative Applications for Biochar Utilization</b> (Application and benefits of biochar in food production systems; Biochar based fertilizers; Impact on Soil Health; Soil biodiversity; Production economics) <b>Chairman:</b> Dr. B. N. Patil, Former ADR, UAS, Dharwad <b>Co-Chairman :</b> Dr. K. Manjappa, University Head (Agro.), UAS, Dharwad <b>Rapporteurs :</b> Dr. S. A. Biradar, Professor of Agronomy Dr. R. A. Nandagavi, Prog. Co -ordinator, KVK, Bagalkote	
<b>Time</b>	<b>Speakers</b>	<b>Topic</b>
<b>15.30-15.50</b>	<b>Dr. Vikas Abrol</b> Professor (Soil Science) SKUAST -Jammu -180009, J & K	Nanobiochar for efficient waste valorization, sequestering carbon and soil fertility management.
<b>15.50-16.05</b>	<b>Dr. Leena V. Hublikar</b> Asst. Professor (Chemistry) KLE Tech University, Hubballi	Fortification of Biochar by nanoparticles for water filtration, energy and agricultural applications
<b>16.05-16.20</b>	<b>Dr. H. K. Joshi</b> , NAU, Navsari	Assessing <i>Prosopis juliflora</i> biochar quality and its synergistic effect with gypsum on yield attributes of rice and wheat under coastal soils
<b>16.20-16.30</b>	<b>P. Ashoka,</b> UAS, Dharwad	Assessing of different decomposers with biochar in sugarcane trash management for enhancing ratoon sugarcane ( <i>Saccharum officinarum</i> L.) yield
<b>16:30-16.40</b>	<b>Ms. Gayathri P. K</b> UAS, Dharwad	Mg(ion)-Modified Biochar for Nutrient Supply in Soil
<b>17.00-18.00</b>	<b>PANEL DISCUSSION</b>	
<b>20.00-21.30</b>	<b>Dinner</b>	
<b>Day-2 : 06-12-2024 (Venue: V C Conference Hall, UAS Dharwad)</b>		
<b>9.30-11.00</b>	<b>Theme 3. Carbon Credits and Market Mechanisms</b> (Carbon credits and incentivizing; Guidelines and Policy issues; Carbon trading and markets, Trading mechanisms; Networking and discovering new market opportunities, Success stories and lessons learned from agricultural carbon credit projects) <b>Chairman:</b> Dr. V. S. Korikanthimath, Former Director, ICAR Res. Complex, Goa <b>Co-Chairman :</b> Dr. R. Basavarajappa, Director of Extension, UAS, Dharwad <b>Rapporteurs :</b> Dr. P. S. Pattar, Professor of Agronomy, AC, Dharwad Dr. B. S. Yenagi, Sr. Scientist & Head, AICRP (Oil seeds)	
<b>Particulars</b>	<b>Name</b>	<b>Topic</b>
<b>9.30-9:50</b>	<b>Dr. Ram Swaroop Meena,</b> Department of Agronomy, Institute of Agricultural Sciences, BHU, Varanasi (UP)	Carbon credits potential in Indian Agriculture to regenerate soil and enhance the farmers' income: An overview and policy framework



<b>9.50-10.05</b>	<b>Dr. Srikanth Vishwanath (Presenter:Dr. Priyanka Sathe)</b> , Mash Makes Product Owner: Biochar and Carbon Removal	Biochar Research: Bridging the gap between Agricultural Challenges and Market Opportunities.
<b>10.05-10.20</b>	<b>Dr. V. C. Patil</b> Managing Director Sagaranadu Sattvic Foods LLP Rajankollur, Dt: Yadgir	Biochar and Bio -Oil production using crop residues and voluntary carbon credits – A case study
<b>10.20-10.35</b>	<b>Mr. Ashis Panigrahi</b> Carbon Market and Traceability Expert	Enhancing Trust in Carbon Offset Initiatives :Leveraging Technology for Traceability and Accountability in Biochar - Based Carbon Sequestration
<b>10:35-10.45</b>	<b>Dr. C. M. Biradar</b> CMD, Global Green Growth	Building resilience with regenerative agriculture: catalyzing soil carbon for green economic growth
<b>10.45–10.55</b>	<b>Dr. Sourabh Munnoli,</b> UAS, Dharwad	Carbon budgeting, energy analysis and economics of nutrient management practices in sugarcane
<b>10.55-11.15</b>	<b>Dr. S. N. Bhat,</b> UAS, Raichur	Long-term effect of different production systems on fractions, indices and sequestration potential of carbon in surface soils of Vertisol
<b>11.15- 11.40</b>	<b>Tea Break</b>	
<b>11.40- 13.30</b>	<b>Theme 4. Regenerative and Carbon -Neutral Farming Systems: ( Integrating Agro-forestry, Conservation Agriculture, Organic Practices and Leveraging Digital Platform for Climate-Resilient Agriculture)</b> <b>Chairman:</b> Dr. B. M. Chittapur, Former DE, UAS, Raichur <b>Co-Chairman:</b> Dr. H. B. Babalad, Chair Professor, Dr. S. V. Patil Foundation, UASD <b>Rapporteurs:</b> Dr. C. P. Chandrashekhara, Professor of Agronomy Dr. Santosh Onte, SMS (Agronomy), KVK, Dharwad	
<b>Particulars</b>	<b>Name</b>	<b>Topic</b>
<b>11:50-12.05</b>	<b>Dr. Hanamant M Halli</b> ICAR-NIASM, Baramati, Maharashtra	Restoration of degraded lands with fruit -based systems to achieve carbon neutrality and Land Productivity in Semi-Arid conditions.
<b>12.05-12.20</b>	<b>Mr. Sandeep Sabharwal,</b> Director, Sanga Chadvam- Foundation, Hubballi	Biochar: a sustainability tool in the hands of farming community
<b>12.20-12.35</b>	<b>Dr. Ramesh Bhat</b> Editor, Publication Centre UAS, Dharwad	Biotechnology-Driven Insights into Biochar Production, Carbon sequestration and carbon trading for Carbon Neutral Farming
<b>12.35-12.50</b>	<b>Mr. Niraj Kheti,</b> Bihar	Agroforestry as a Pathway to Ecological Farming and Land Regeneration: Field Experiences from Bihar
<b>12.50-13.10</b>	Poster Session / visit to exhibition / demonstration	
<b>13.10-14.15</b>	<b>Lunch Break</b>	
<b>14.45-16.30</b>	Poster Session / visit to exhibition stalls / demonstration	
<b>16:30-16.45</b>	<b>Tea Break</b>	
<b>16.45-17.45</b>	<b>Closing Session</b>	



**Proceedings of the First National Seminar on  
“INTEGRATING BIOCHAR PRODUCTION, CARBON SEQUESTRATION AND  
CARBON TRADING FOR A CARBON NEUTRAL FARMING”**  
organized by Dr. S.V.Patil Foundation and University of Agricultural Sciences, Dharwad  
from 05-06 December, 2024

**INAUGURAL SESSION**



Initiation of interdisciplinary research focusing on biochar's role in soil health is the need of the day said Dr. P. Chandrasekhar Rao, Former Dean (PGS), PJTSAU, Hyderabad, inaugurating the first National Seminar on “Integrating Biochar Production, Carbon Sequestration and Carbon Trading for a Carbon Neutral Farming” organized by Dr. S.V.Patil Foundation and University of Agricultural Sciences, Dharwad with the financial support of NABARD, REWARD, KVG Bank, UAS-Raichur and Ugar Sugars Pvt. Ltd., on 05 and 06 December 2024 at UAS, Dharwad. Reflecting on the success of the Green Revolution in the 1970s through rice and wheat cultivation supported by fertilisers, pesticides and irrigation, he noted that by the 1980s, indiscriminate input use led to soil health deterioration, resource depletion and multi-nutrient deficiencies, further exacerbating climate change. He highlighted the alarming state of soil organic carbon and emphasized the potential of biochar in improving soil health, carbon sequestration, pollutant adsorption and organic farming practices, while urging multidisciplinary research. He also proposed the formation of a Biochar Society of India to promote focused research, collaboration and sustainable practices.

**Dr. B. N. Aravinda Kumar**, Professor of Agronomy, UAS, Dharwad and Organizing Secretary of the seminar welcomed the dignitaries, guests and participants of the National Seminar, organized by Dr. S.V. Patil Foundation and the University of Agricultural Sciences, Dharwad. He highlighted the seminar's focus by addressing climate change and promoting sustainable agriculture. Special welcome was extended to the Chief



Guest, Dr. R. Chandrasekhar Rao, Dr. P.L. Patil Vice-Chancellor UAS Dharwad, Dr. M.N. Shelvantar former Vice-Chancellor UAS Bangalore, Dr. V.C. Patil for his work on biochar technology and Dr. H.B. Babalad's contributions to climate-resilient agriculture. Dr. B.N. Aravinda Kumar also introduced Dr. P.C. Rao and acknowledged his significant contributions to soil science and the mentoring of numerous scholars. This seminar aimed to advance sustainable and carbon-neutral farming practices.

**Dr. H. B. Babalad, Chair-Professor, Dr. S. V. Patil Foundation**, expressed that the '*Dr. S.V.Patil Foundation for Research, Training and Farmer's Welfare*' was established in 2022 during the centenary year of Dr. S.V.Patil to honor his legacy and ideals. This foundation was formed with contributions from his well-wishers, students, family members and the farming community under the auspices of the University of Agricultural Sciences (UAS), Dharwad. Dr. S.V.Patil was a renowned Agricultural scientist, teacher, academician, visionary and institution builder par excellence who significantly contributed to the development of College of Agriculture Dharwad, transforming it into a university in 1986 to address agricultural research, education and farmer welfare in northern Karnataka. He also initiated agroforestry research at UAS Dharwad as early as 1972 and played a pivotal role in establishing institutions, such as the College of Agriculture, Raichur and the College of Veterinary Science, Bidar, which later emerged as universities.

The foundation's primary objectives include promoting climate-resilient agro-ecological farming, developing smart farming solutions and supporting secondary agriculture to improve farmer's livelihood security. Several notable activities were organised under its banner, beginning with the curtain-raiser event on 25 February 2022 followed by the First National Seminar on “**Sustainable food production systems for self reliant and Climate resilient Agriculture**” in collaboration with ICAR, UAS Dharwad and other farm universities in Karnataka. The centenary celebrations of Dr. S.V.Patil held on July 18, 2022, were graced by dignitaries including Dr. Ashok Dalwai, Former CEO, National Rainfed Area Authority, GoI, New Delhi, Dr. M. B. Chetti, Vice-Chancellor, UAS, Dharwad, Dr. Rajendra Prasad, Vice-Chancellor, UAS, Bengaluru, Dr. K. N. Kattimani, Vice-Chancellor, UAS, Raichur, Dr. K. C. Veeranna, Vice-Chancellor, KVAFSU, Bidar, Dr. Geetha Lakshmi, Vice-Chancellor, TNAU and others.

In 2023, the Government of Karnataka sanctioned one crore to establish '**Dr. S.V.Patil Chair**' which was inaugurated by Chief Minister Shri. Basavaraj Bommai. Subsequent activities included the adoption of Hulkund Village, Dr. S. V. Patil's birth place, various development initiatives and the institution of gold medals in his memory to outstanding students at UAS Dharwad.

The foundation also undertook research and training projects, such as agro-ecological studies with ICCOA Bangalore and evaluation of FPOs in collaboration with SFAC, Ministry of Agriculture and Farmers' Welfare, GOI. Dr. Babalad highlighted that the foundation provided a platform for collaborative research, training and advisory support, thus complementing efforts of UAS Dharwad. The Second national seminar





reflected the foundation's ongoing commitment to advancing agricultural innovation and supporting the farming community. Dr. Babalad thanked the organizers for the opportunity to share these thoughts.

**Dr. V. C. Patil**, Former Dean (Agri), UAS, Raichur and Founder Member of the Foundation expressed his views on the evolving significance of biochar, describing it as "black gold" and tracing its origins to terra preta soils of the Amazon. He highlighted its potential for climate mitigation, soil sustainability and productivity, particularly in addressing challenges such as crop residue burning and environmental pollution. He emphasised that biochar production still faces several bottlenecks, such as feedstock availability, biomass handling and the need for consistent supply chains to meet industrial and agricultural demands.

Dr. Patil noted that pyrolysis remains the most efficient method for biochar production because of its ability to produce bio-oil and syngas as byproducts, with bio-oil showing promise as a plant growth promoter and biopesticide. He also raised concerns that biochar might be diverted more towards industrial applications, such as a coal substitute, due to policy shifts and market dynamics, rather than being used for soil enrichment. He acknowledged the leadership of experts such as Dr. Mehta and Dr. Sai Bhaskar Reddy in promoting biochar through events and initiatives such as the Progressive Biochar Society, Hyderabad. He also highlighted the importance of carbon credits, which has made biochar a viable proposition in recent years. Dr. V.C. Patil urged researchers to focus on the practical application of biochar in farming systems, especially in soil remediation, heavy metal absorption and soil health improvement. He stressed the need for collaboration among agronomy, soil science and microbiology faculties to advance biochar research and utilisation.

He called upon state agricultural universities, including the host institution, to play a proactive role in developing the biochar sector in collaboration with organisations such as Dr. S. V. Patil Foundation. He concluded by thanking the organisers and emphasising the importance of documenting and addressing policy issues for the benefit of farmers.

**Dr. M. N. Sheelavantar**, Former Vice-Chancellor, UAS, Bangalore and the Founder Member of the Foundation, emphasised critical challenges in soil and water conservation, drawing attention to persistent issues despite decades of discourse and initiatives. He highlighted the decline in soil organic carbon due to the absence of sustainable practices, such as crop rotation and residue recycling, urging collaborative responsibility among scientists, administrators and governments to address these concerns effectively. Furthermore, he appreciated the practical wisdom of Late Dr. S. V. Patil's philosophy was rooted in the Gandhian ideals of simplicity, service and a farmer-centric approach to agricultural advancement.

Dr. Sheelavantar also discussed the significance of biochar as a means of addressing climate change and enhancing carbon sequestration. He exhorted researchers to focus on pragmatic solutions for farmers. Citing Dr. Norman Borlaug, he reiterated that the field must be the priority, emphasising that plants communicate with those who observe them attentively. He concluded by urging the agricultural community to honour and elevate farmers, aligning with the Late Dr. S. V. Patil's vision of a more equitable and sustainable farming system.

In his presidential address, Vice-Chancellor **Dr. P. L. Patil**, who is also the President of the Foundation, commended the visionary leadership of Dr. V.C. Patil, who initiated biochar research and applications on his farm. Dr. V.C. Patil's characterisation of biochar as "black gold" underscored its potential in improving soil health, mitigating climate change and enhancing carbon sequestration. He acknowledged Dr. S.V. Patil Foundation's expeditious progress in organising two National Seminars and securing significant projects. He also commended the seminar's focus on biochar as a tool for sustainable agriculture and carbon-neutral farming. He emphasised the importance of collaborative research, practical applications and policy frameworks to advance biochar technology. Dr. Patil recognised the participants' shared enthusiasm for utilising biochar in addressing climate challenges while promoting environmentally sustainable farming practices.





**Dr. I. K. Kalappanavar**, Dean (Agri.) and the Vice President of the Foundation extended vote of thanks at the biochar seminar. He also appreciated to Dr. P. Chandrasekhar Rao, for his informative presentation, acknowledged Vice Chancellor's support in facilitating the event. He also recognised Dr. M. N. Sheelavantar, Dr. V.C. Patil, Dr. H.B. Babalad and Dr. B. N. Aravind Kumar for their active participation and support. Acknowledgement was extended to the Progressive Biochar Society, Hyderabad, delegates from Norway and all participants from across the country for their contributions.

### **Inaugural Address by Dr. P. Chandrasekhar Rao**

Dr. P. Chandrasekhar Rao, Former Dean (PGS), PJTSAU, Hyderabad, delivered the inaugural address. He elucidated the contributions of Dr. S. V. Patil Foundation, which were expected to play a crucial role in realising the vision and objectives to which Dr. S. V. Patil had dedicated his life. Dr. Rao emphasised that these endeavours would significantly enhance the quality of agricultural research, teaching and technology dissemination. He expressed his satisfaction having previously delivered a lecture on biochar for sustainable agriculture, reaffirming his commitment to the subject.

Dr. Rao reflected on the initial Green Revolution of the 1970s, which was primarily achieved through the extensive cultivation of rice and wheat, supported by fertilisers, pesticides and irrigation. However, by a 1980s, the indiscriminate utilisation of these inputs, coupled with the reduced application of organic manure resulted in a significant decline in organic carbon content, depletion of natural resources, multi-nutrient deficiencies and soil degradation. Collectively, these factors contributed to global climate change. The critical state of soil organic carbon was highlighted, with over 90% of soils reportedly containing less than 0.3% organic carbon. The nation experienced an annual loss of 54 billion tons of fertile topsoil due to erosion. Dr. Rao emphasised that the formation of just one acre-centimetre of soil required 400 to 600 years, underscoring the significance of the issue.

The global efforts of Sadguru Jaggi Vasudev in advocating the campaign were specifically acknowledged. Dr. Rao commended his comprehensive survey across 30 countries, covering 30,000 km, which effectively raised awareness among policymakers regarding the critical need to address declining soil organic carbon levels. The discourse centred on the substantial potential of biochar to address challenges in agriculture, energy, health and the environment. Although the agricultural applications of biochar were recognised as promising. He cautioned that the field remained in its nascent stages. He emphasised the necessity for multidisciplinary and interdisciplinary research prior to formulating specific recommendations.

Various applications of biochar, including its utilisation in water treatment, air purification, food preservation and co-composting, were elucidated. The historical and cultural significance of biochar was also expounded upon, with participants noting its traditional use in spiritual practice. Biochar's role as bedding material for livestock management, its capacity to adsorb gases such as ammonia and carbon dioxide and its potential to enhance compost quality were particularly noteworthy. The discussion encompassed the contributions of biochar to carbon sequestration, soil temperature regulation, moisture retention and nutrient management in agricultural systems. The importance of comprehending biochar properties, determined by feedstock, pyrolysis methods and post-treatment processes was emphasised. Key physical properties, including particle size, bulk density, pore volume and surface area, were examined in relation to their effects on the soil.

The chemical properties of the biochar, including its alkaline pH, high cation exchange capacity and nutrient-rich composition, were highlighted. These characteristics have been shown to enhance soil fertility, ameliorate acidity and attenuate heavy metal contamination. The biological advantages of biochar, particularly its beneficial effects on microbial activity and biodiversity, have also been recognised.

Rao elucidated the efficacy of biochar as an adsorbent, attributing its utility to its extensive surface area and amenability to surface modifications. The capacity of biochar to adsorb heavy metals, organic dyes, pharmaceuticals, pesticides and industrial effluents is an emerging area of research interest. However, Dr. Rao



emphasised the necessity for comprehensive studies on biochar production and utilisation, encompassing quality assessment, standardisation and detailed investigations into adsorption-desorption behaviours. Furthermore, he highlighted the potential application of biochar in natural and organic farming systems, particularly when integrated with co-composting processes. Incubation and pot culture experiments focusing on temperature, moisture and nutrient fixation-release patterns are proposed as crucial areas for further investigation.

The challenges associated with biochar, including the potential overexploitation of biomass and necessity for accessible technologies for small and marginal farmers, were extensively discussed. Participants advocated for the documentation of traditional biochar practices, development of cost-effective biocomposting processes and implementation of rigorous regulations to ensure sustainable practices. Dr. Rao proposed the integration of biochar applications into ongoing long-term fertiliser experiments conducted by ICAR to investigate its comprehensive effects on soil and crop systems. He suggested the establishment of a professional organisation, such as the Biochar Society of India, to facilitate focused research, promote collaborations and disseminate findings through specialised journals.

The event concluded with the publication of the seminar compendium and the participants expressed their appreciation to the organisers for facilitating substantive discussions. Dr. Rao's address served as a compelling impetus for continued research and collaboration in harnessing the potential of biochar for sustainable agriculture and climate change mitigation.

### Recommendations

1. Strengthen partnerships between academic institutions, government bodies, private stakeholders and international organisations to enhance biochar research, production and global best practices.
2. Advocate supportive policies, such as incentives or tax benefits, develop national guidelines and establish quality testing facilities for standardised biochar production and application.
3. Promote sustainable biomass utilisation, optimise pyrolysis techniques and integrate biochar into organic farming and co-composting systems.
4. Training programs, workshops and awareness campaigns for farmers, civic societies and media should be organised to highlight the benefits of biochar and promote its grassroots adoption.
5. Facilitate seminars, pilot projects and publications while monitoring the environmental impacts of biochar and exploring applications in non-agricultural sectors, such as water treatment and waste management.
6. Establish a Biochar Society of India to coordinate national efforts, document traditional practices and integrate indigenous knowledge with modern biochar techniques.

### Technical Session-1: Biochar for Environmental Sustainability and Climate Action (Policies, Practices and Commercial Perspectives)

**Chairperson:** Dr. P. Chandrasekhar Rao, Former Dean (PGS), PJTSAU, Hyderabad

**Co-Chairperson:** Dr. B.D. Biradar, Director of Research, UAS, Dharwad

**Rapporteurs:** Dr. M. P. Potdar, Chief Scientist, AICRP(DLA), Vijayapur

Dr. Shivamurthy D., Agronomist, ARS, Nippani

**Lead Speakers:** Mr. R. K. Mehta, Founder, Progressive Biochar Society, Hyderabad

Dr. N. Sai Bhaskar Reddy, President, Progressive Biochar Society, Hyderabad

Dr. Madhukar Potdar, Founder Maha-Dragon Assoc. Pune

Dr. Kul Rora, Director, Circonomy Bio-Waste Solutions, Pvt. Ltd. Singapore

Dr. Anil Chowk, CEO Sanjeevini Agro, Nagpur

Mr. Sumukh K. Bhat, Nullwaste Industries Bengaluru



## 2.1 Dr. R.K. Mehta, Founder of the Progressive Biochar Society, Hyderabad

Dr. R.K. Mehta, Founder of the Progressive Biochar Society, Hyderabad, shared his insights and extended warm greetings to the organisers of the National Seminar on Biochar and agricultural specialists. In a thought-provoking address, he emphasised the pivotal role of biochar in tackling global challenges, drawing from their extensive experience as a “biochar crusader”.

Emphasising the significance of biochar in addressing global challenges, he elucidated its potential to mitigate climate change and its interdisciplinary applications involving professionals from diverse fields. Drawing upon international experience, he underscored the urgency of addressing carbon dioxide emissions and advocated for agricultural engineers' proactive involvement in facilitating biochar production and application.

Society's inception on 13 February 2024 was recounted, highlighting its swift expansion to 280 active members with branches throughout India. He expounded on the extensive potential of biochar, noting nearly 100 documented applications that warrant further scientific investigations. He emphasised the critical role of biomass sources in biochar production. The announcement of society's upcoming national seminar in April 2025, centred on biochar applications, was made. Dr. Mehta concluded by imploring stakeholders to consider biochar as a viable solution for addressing climate change and promoting sustainable development.

Over the past 15 years, substantial advancements have been achieved by research and development centres in India, including ICAR, CSIR, agricultural universities and other agro-organisations, with numerous pilot production plants already operational. Research in this domain is extensive, with 6,000 global publications in the previous year, of which 30% pertain to agriculture. Despite the economic feasibility demonstrated by ICAR through long-term projects, the dissemination of results was limited due to funding and governmental constraints.

The advancement of the biosphere sector in India has been championed by prominent personalities such as Dr. Bhaskar Reddy and entities such as the Progressive Biochar Society. Their endeavours encompassed a series of educational events, including four seminars and three webinars, as well as collaborative efforts with institutions, such as the Murugappa Research Centre, Chennai. The significant outcomes of these initiatives include the promotion of bamboo biochar, which is renowned for its substantial carbon sequestration capabilities and the implementation of block plantations to ensure a consistent supply of biomass.

The Progressive Biochar Society has expanded its presence nationally with initiatives to establish regional affiliates and increase membership. Hyderabad's Biochar Club has been instrumental in promoting biochar production, with organisations such as Dr. Reddy's Foundation committing to establishing pyrolysis facilities and advocating the integration of biochar into policy frameworks.

International collaborations are proliferating, with organisations such as the International Biochar Initiative (IBI) and the United States Biochar Initiative (USIB) assuming pivotal roles. These entities host well-attended conferences and disseminate cutting-edge research through newsletters.

In India, the established applications of biochar include agricultural biofertilisers, animal feed additives, carbon credit generation and syngas production. Entrepreneurs have demonstrated the economic feasibility of biochar production with governmental support, such as capital subsidies in Punjab, facilitating adoption. The establishment of industrial biochar units and private R&D centres is anticipated to drive future growth, providing employment opportunities for technicians, field officers and factory managers.

Governmental intervention is essential for scaling biochar adoption through authorised centres, investment subsidies and integration into fertiliser distribution schemes. The potential applications of biochar in steel manufacturing, soil remediation, animal feed and building materials continue to expand, reinforcing



its significance in sustainable development. Dr. Mehta highlighted the potential of biochar to combat climate change, urging widespread promotion and collaboration within the biochar community.

### Recommendations

1. Interdisciplinary partnerships among academia, government and private sectors should be encouraged to advance biochar research and its applications in addressing climate and agricultural challenges.
2. Conduct seminars, workshops and trainings for farmers and engineers to elucidate the benefits and practical applications of biochar across sectors.
3. Advocate for subsidies, tax benefits and sustainable biomass sourcing policies to boost biochar production and adoption for long-term environmental and economic benefits.
4. Enhance research and development collaboration with agricultural universities, global organisations and the private sector.
5. Advocate governmental policies that support subsidies, incentives and procurement of biochar.
6. Establishing training centres for capacity building in biochar production and utilisation.
7. Facilitate the promotion of awareness and market development of biochar applications in agriculture and industry.

### Remarks by Dr. Nakka Sai Bhaskar Reddy, President, Progressive Biochar Society, Hyderabad

Dr. Reddy elucidated his comprehensive perspectives on the challenges and opportunities associated with biochar, highlighting his research trajectory since 2005 when he initially commenced work on this subject. He emphasised the necessity for a National Biochar Policy and Standards in India, understanding the imperative nature of such a framework to ensure progress. Drawing comparisons with pollution standards for vehicles in developed and developing nations, he noted that biochar standards are predominantly designed for countries such as the United States, Canada, Europe and Australia, where biochar movement is more advanced. He underscored the importance of adopting optimal technologies globally,



as encouraged by the Kyoto Protocol's Clean Development Mechanism (CDM) and observed the difficulty in developing countries for immediate transition to high-end technologies. Citing his own experiences of training communities in biochar production using methods ranging from rudimentary matchbox techniques to sophisticated pyrolysis technologies, he emphasised the complexities of determining which technology to adopt, given the diverse options and varying cost implications.

He elaborated on the lack of consensus regarding the definition of biochar, pointing out the relatively recent adoption of the term since 2007 and the confusion it causes among various stakeholders including forest departments, pollution control boards and taxation authorities. This lack of clarity impedes efforts to differentiate biochar from analogous products, such as charcoal or compost, particularly at the agricultural level. The speaker emphasised the necessity for standardised biochar products, advocating the integration of biochar production with existing frameworks while phasing out inefficient technologies. The historical progression of efficiency improvements in other domains, such as vehicle emissions, was highlighted and a similar gradual approach to biochar production was proposed.



Reddy identified fragmented jurisdiction, lack of awareness and the absence of a policy framework as significant barriers to the financial support required for biochar initiatives. He highlighted the challenges pertaining to standardisation, certification and unrealised opportunities for economic and environmental benefits. Furthermore, he discussed the competition for biomass resources driven by government policies on biofuels, biogas and other renewable energy initiatives that present obstacles to the economic viability of biochar. The high cost of biochar production, particularly when compared to more economical alternatives, such as urea and compost, further impedes its adoption. He emphasised the importance of integrating biochar into government programs, such as the Soil Health Card Scheme, the Sustainable Agriculture Mission and the Pradhan Mantri Krishi Sinchayee Yojana, given the potential of biochar to enhance water use efficiency and soil health.

Furthermore, Dr. Reddy advocated for enhanced awareness and education among stakeholders, ranging from policymakers to farmers, regarding the utilisation of biochar. He cautioned against the potential long-term detrimental effects on soils if biochar is misused or overapplied, noting that its impact could persist for centuries. He proposed the establishment of production standards, feedstock regulations and accessible cost-effective testing laboratories to ensure quality control. Emphasising the necessity for a unified national organisation to coordinate biochar initiatives and encourage adaptation, he suggested policy measures, such as financial incentives for farmers, carbon credits and green credits to promote biochar adoption. He also underscored the importance of implementing accountability mechanisms and raising awareness about the environmental and social implications of biochar use. In conclusion, he emphasised the urgency of addressing these challenges through collaborative efforts and integrating biochar into India's policy framework to realise its potential benefits for agriculture, the environment and climate change mitigation.

### Recommendations

1. *Develop a National Biochar Policy:* Create clear guidelines and standards for biochar production, quality and safe use in agriculture.
2. *Raise awareness and build skills:* Conducting training programs and workshops to educate farmers, policymakers and stakeholders on the benefits and proper use of biochar.
3. *Incorporation of biochar into government programs:* Include biochar in schemes such as the Soil Health Card and Sustainable Agriculture Mission to promote its use in improving soil and water management.
4. *Provide Financial Support:* Offer subsidies, carbon credits, or incentives to farmers and industries adopting biochar technologies.
5. *Ensure quality control:* Establish testing laboratories and certification systems to maintain the quality of biochar and regulate its application for long-term benefits.

### Remarks by Dr. Madhukar Potdar, Founder, Maha-Dragon Association, Pune, Maharashtra

Dr. Madhukar Potdar's conference participation was facilitated by Dr. R. K. Mehta's introduction to the biochar crusader group. This event constituted Dr. Potdar's third visit to Karnataka, following his previous engagements at the regenerative agriculture conference at Gadag University.

The individual elucidated the differentiation between charcoal and biochar, accentuating the biological and plant-derived origin of biochar and its importance in sustainable practices. Dr. Potdar expounded upon his research in the Kutch region, the largest district in India, which is characterised by arid conditions, saline soils and distinctive ecosystems. Notwithstanding challenges such as low precipitation and high salinity, the region sustains biodiversity, tourism and agriculture.

The introduction of the *Prosopis* as a biological reclamation measure by the Maharaja of Bhavnagar and the Gujarat government resulted in its successful proliferation and integration into local ecosystems and livelihoods. Maharaja expounded upon the species' capacity for charcoal production and soil amelioration, highlighting its contribution to biodiversity enhancement and the promotion of sustainable agricultural methodologies.



Dr. Potdar pointed out the historical significance of biochar, drawing parallels to 7,000-year-old terra preta soils in the Amazon. He elucidated the experimental work conducted by his research team in saline and arid conditions utilising biochar to enhance soil health and carbon sequestration. Successful trials encompassed various drought and salinity-tolerant crops including castor, sesame, bajra and sandalwood. He underscored the importance of applying biochar to the root zone to obtain efficacious results.

Furthermore, he emphasised the significance of Crassulacean Acid Metabolism (CAM) species such as *Hylocereus undatus*, *Opuntia spp.* and *Agave spp.* in carbon sequestration under arid conditions. These investigations have elucidated the potential of biochar and drought-tolerant crop species to augment productivity and sustainability in challenging environments, such as Kutch.

### Recommendations

1. *Increased Awareness*: Educate stakeholders on the role of biochar in improving soil health, carbon sequestration and water retention.
2. *Integrate traditional knowledge*: Utilise practices such as terra preta to improve soil productivity in degraded areas.
3. *Leverage Local Resources*: Investigate drought- and salinity-tolerant crops that thrive in arid environments to maximise land use in regions such as Kutch.
4. *Sustainable Land Reclamation*: Use native species such as *Prosopis juliflora* for soil reclamation and biodiversity improvement in saline soils.
5. *Maximise Benefits of Prosopis juliflora*: View *Prosopis sp.* as a resource for biochar production, livestock feed and energy solutions, rather than as an invasive species.
6. *Wasteland Restoration*: Use of trench-based reclamation methods and biomass management for efficient land restoration.
7. *Promote sustainable use*: Encourage the use of *Prosopis sp.* for charcoal, which can help to reclaim land and provide valuable biomass for energy.
8. *Test Biochar Techniques*: Conduct research to identify the best methods for applying biochar, especially in saline or degraded soils, for better agricultural outcomes.
9. *Combined with Other Inputs*: Test combinations of biochar with compost, fertilisers, or biological additives to optimise nutrient uptake and soil quality.
10. *Focus on Drought Tolerant Crops*: Invest in research for crops such as castor, sesame and bajra, which are known for their tolerance to dry conditions and suitability in arid regions.
11. *Explore CAM Plants*: Promote plants such as dragon fruit, cactus and agave, which perform well in water-scarce environments and offer potential for carbon sequestration.
12. *Track Carbon Storage*: Regularly monitor both aboveground and belowground carbon storage to measure the effect of biochar on soil carbon.

### Remarks by Mr. Kul Rora, Director of Circonomy Bio-Waste Solutions Pvt. Ltd. Singapore

Mr. Kul Rora, The Director of Circonomy Bio-Waste Solutions Pvt. Ltd. Singapore and Logistical Technologies Pvt. Ltd., delivered a presentation on the significance of smallholder farmers in mitigating climate change through carbon credit initiatives. He drew attention to the pressing concern about biomass combustion and its impact on climate change, emphasising the looming threats to India's food security. His organisation specialises in the application of biochar to tackle these environmental challenges. He elucidated the contrast between carbon avoidance and carbon sequestration, highlighting that biochar, when manufactured at





elevated temperatures, can effectively sequester carbon for up to a millennium, offering a more enduring solution than alternative approaches such as afforestation, which exhibit limited longevity. He further noted that even rudimentary biochar production techniques can yield carbon credits, provided they meet specific carbon retention standards. To streamline this process, his company engineered a Digital Monitoring, Reporting and Verification (DMRV) system. Circonomy is currently engaged in numerous projects across India, fostering partnerships with farmers and providing financial incentives through carbon credits for biochar production. The firm has intensified its efforts to expand these initiatives with the objective of equipping farmers with sustainable agricultural practices.

Mr. Kul Rora emphasised the significance of smallholder farmers in climate change mitigation through carbon credits. He elucidated the critical issue of biomass burning and its contribution to climate change, underscoring imminent risks to food security in India. His organisation focuses on utilising biochar to address these challenges. He expounded on the distinction between carbon avoidance and carbon removal, noting that biochar, when produced at high temperatures, sequesters carbon up to 1,000 years, offering a long-term solution compared to other methods such as afforestation, which have limited permanence. He further elucidated that low-technology methods of biochar production can still generate carbon credits, provided certain carbon retention criteria are met. His organisation developed a Digital Monitoring, Reporting and Verification (DMRV) tool to facilitate this process. Circonomy operates multiple projects in India, collaborates with farmers and provides financial incentives to produce biochar through carbon credits. The organisation has expanded its efforts to scale these projects, aiming to empower farmers with sustainable solutions.

Mr. Kul Rora emphasised the significance of biochar production in facilitating the generation of carbon credits for smallholder farmers. His organisation establishes connections between farmers, third-party auditors and relevant standards to ensure the issuance of carbon credits for the produced biochar. He elucidated that farmers engaged in biochar production are the proprietors of the credits, provided that the biochar is not combusted, as combustion releases the sequestered carbon back into the atmosphere. Instead, biochar must be applied to the soil or amalgamated with other substances to render it non-combustible, thereby securing carbon credits.

The utilisation of biochar in soil can be implemented on multiple occasions throughout the year, with agricultural practitioners receiving credits for each application. This measurable process facilitates the monetisation of credits, with initial valuations commencing at \$90 per unit, thereby generating a direct financial benefit for farmers. Notably, these proceeds are exempt from income tax because they are classified as agriculture-related revenue.

Circonomy facilitates the development of agricultural practitioners' expertise in sanctioned biochar production methodologies and ensures compliance with carbon credit standards. This program enables farmers to generate substantial revenue while contributing to climate-change mitigation initiatives.

He illuminated the intricacies of biochar production, underscoring the necessity for both certified apparatus and proficient operators. They elaborated that the procedure entails the precise stratification of biomass and the maintenance of appropriate combustion conditions to achieve pyrolysis, which is crucial for high-grade biochar. The requisite equipment, such as conical pits or kone-tikis, is engineered to attain temperatures of up to 900°C, thereby ensuring that the biomass undergoes pyrolysis rather than combustion, resulting in a significant increase in carbon content.

The speaker emphasised that for biochar to be eligible for carbon credits, it must possess a carbon-to-hydrogen ratio (H/C) of less than 0.4, indicating that low-carbon biochar does not meet the criteria. The representative noted that their organisation rigorously monitored the production process and rejected batches that did not meet the required standards, citing the rejection of 30 tons of biochar in the previous year due to non-compliance.

Addressing concerns regarding pollution, Mr. Rora elucidated that while some pollution is inevitable, the process circumvents complete combustion, thereby preventing the release of deleterious gases. The critical factor in successful biochar production is the quenching process, which requires precise timing to prevent the conversion of biomass into ash and carbon dioxide.



He acknowledged the challenge of scaling biochar production to an industrial level, particularly in the hot climates of Karnataka and Telangana and discussed the feasibility of industrial-scale units for carbon credits.

Mr. Kul Rora provided insights into the challenges and progress of biochar production, particularly in the warmer climates of Karnataka and Telangana. Initially, with a background in software engineering with limited agricultural expertise, he elucidated the difficulties in introducing industrial pyrolysis equipment in India owing to high costs and unfamiliarity. The company commenced with artisanal biochar production, utilising a pilot project to comprehend the challenges and market dynamics. They distributed biochar at no cost to farmers, who subsequently expressed interest in purchasing it for soil application, indicating an emerging market for biochar-based fertilisers.

He emphasised that while they are prepared to transition to closed equipment, certified equipment for carbon credits is not currently available in India. They intend to collaborate with equipment providers to ensure that the utilisation of these devices can yield carbon credits. Rather than focusing on large industrial plants, which are impractical due to high costs and logistical challenges, the company is progressing towards mid-tech equipment, which can process 2-3 tonnes per day, utilising agricultural residues

The individual also elucidated the strategy for scaling biochar production, noting that the organisation intends to collaborate with agriculturists utilising artisanal methods while transitioning to more centralised, intermediate-technology equipment for large-scale production. It was stated that the operational costs ranges from \$55 to \$80 per ton and with carbon credit trading at \$90 to \$100, the venture remains economically viable. Furthermore, several organic fertiliser manufacturers have expressed interest in incorporating biochar to develop biochar-based organic manures, thus contributing to the expanding market demand.

He discussed the potential future of biochar-based organic fertilisers, highlighting the gradual reduction in government subsidies over the next 10-15 years, which would make biochar a viable alternative for farmers. He noted that farmers became increasingly aware of soil degradation and the diminishing effectiveness of urea. However, the shift to organic manures faced resistance owing to price differences, with farmers opting for cheaper options. He suggested that carbon credits could incentivize this shift.

They clarified the differences between biochar and charcoal, emphasising that biochar has porosity and water-holding capacity, rendering it suitable for nutrient retention, unlike charcoal, which is valued only for its calorific value. He outlined five key points for biochar advocates: it can help cool the planet, it differs from charcoal due to its porosity and it holds the potential for increasing water retention in soils.

He elucidated his challenges with biochar production, particularly with the DMRV system, which proved problematic in the initial stages. He recounted the anecdote by Dr. V. C. Patil's experience with extreme heat while attempting to measure fire temperature. Additionally, he encountered fire hazards on his farm, resulting in the loss of a substantial quantity of biomass owing to an accidental fire. This incident led to the realisation that biomass should be converted to biochar immediately following collection rather than being stored. This insight is disseminated to assist others in avoiding similar errors.

He acknowledged the complexity of biochar production and the continuous improvements that had been implemented over the preceding year. Despite these challenges, his team collaborated closely with farmers to adapt biochar production methods to their requirements. He emphasised the significance of feedback from field-based personnel and recognised that biochar production methods necessitated adaptation to diverse contexts such as remote and mountainous regions. He concluded by expressing appreciation for the opportunity to disseminate these experiences and insights at the seminar.

#### **Recommendations:**

1. Advocates government subsidies or carbon credit mechanisms to incentivise biochar adoption.
2. Develop strategies to reduce the cost of biochar production, making it more accessible to farmers.
3. Offer subsidies or financial assistance to bridge the price gap between biochar and conventional fertilisers.
4. Implement training programs to educate farmers about biochar's benefits for soil health and water retention.



5. Raise awareness of how biochar can help to mitigate soil degradation and improve long-term yields.
6. Invest mid-tech and closed equipment to improve biochar production efficiency and scalability.
7. Encourage immediate conversion of biomass into biochar to reduce fire hazards and biomass waste.
8. Promote research on soil-specific biochar applications to optimise its effectiveness under varying conditions.
9. Establish feedback channels to gather insights from farmers and producers for system improvement.
10. Working closely with agronomists to create region-specific biochar application strategies.
11. Design of biochar production systems suitable for remote or hilly areas with limited access to advanced equipment.
12. Strengthen partnerships with local farming communities, research institutions and agricultural organisations.
13. Empower smallholder farmers by promoting their involvement in carbon credit programs to mitigate climate change.
14. Implement awareness programs on the detrimental effects of biomass burning on climate change and food security.
15. Advocate the use of biochar as a permanent carbon sequestration method, emphasising its ability to store carbon for up to 1,000 years.
16. Encourage the adoption of low-tech biochar production methods to allow farmers to generate carbon credit.
17. Provide guidelines for meeting carbon retention criteria to ensure the effectiveness of carbon credit programs.
18. Promote the use of Digital Monitoring, Reporting and Verification (DMRV) tools to streamline the carbon credit process for biochar production.
19. Offers technical support and resources for farmers to utilise these tools efficiently for accurate carbon credit documentation.
20. Scale biochar production projects to engage more farmers and extend their reach across India.
21. Offers financial incentives for farmers to produce biochar, linking their efforts to carbon credit schemes.
22. Investment in research to improve biochar production technology and make it more accessible to smallholder farmers.
23. Designing biochar projects tailored to different regions in India, considering local farming conditions and needs.
24. Ensure the scalability of biochar production systems to cater to diverse agricultural landscapes across the country.
25. Work with government bodies to create favourable conditions for the growth of biochar initiatives in agriculture.

### Remarks by Mr. Anil Chouk, CEO of Sanjeevani Agro, Nagpur

Mr. Anil Chouk, CEO of Sanjeevani Agro, Nagpur, presented paper on "Designing, Supply and Servicing of Customised Spiralizers for Biosphere Production." He emphasized principle of making life easy across sectors like healthcare, agriculture and households. A recipient of the prestigious Udyog Bhushan Award from Sakal Media in 2022, Mr. Chouk has been actively working in the biochar sector for over eight years, designing user-friendly biochar machines that are easy to operate. He has supplied more than 80 biochar machines across





India and created over 22,000 entrepreneurs in various sectors, including animal feed, fish feed, biomass pellets, biochar and bamboo. His vision focuses on strengthening rural economies and generating employment in rural areas to curb migration to cities.

During his presentation, Mr. Chouk discussed the innovative machinery developed by Sanjeevani Agro, established in 2016 and its contributions to biochar production and carbon credit initiatives. He highlighted various biochar machine models, including batch and continuous type, with capacities ranging from 50 kg to 16,000 liters. The machines are designed to process diverse raw materials, such as bamboo, coconut shells, cotton stalks and agricultural waste, into high-quality biochar. He also shared success stories, including collaborations with institutions like NIRI, the Maharashtra Bamboo Development Board, NTPC, Tata Steel and the Cotton Research Centre, where biochar machines are actively contributing to sustainable practices.

Mr. Chouk described new developments, such as batch-type rotating models and continuous-type machines with capacities of up to 5 tonnes per hour, designed for efficient and cost-effective biochar production. He mentioned successful trials with various raw materials and their applications in industries like steel, where Tata Steel procures biochar for trials and operations. Highlighting future prospects, he revealed that industries are increasingly placing large orders for biochar, demonstrating its growing demand. Additionally, he showcased projects like the automatic pyrolysis plant in Sirkot and collaborations with organizations such as Mahila Arthik Vikas Mahamandal and GIZ, where biochar machines are used to process cotton, rice straw and other agricultural residues into biochar.

#### Recommendations:

1. Expand awareness and training programs through workshops, multilingual manuals and video tutorials.
2. Strengthen collaboration with research institutions for enhanced biochar technologies and innovative applications.
3. Advocate for government subsidies, incentives and inclusion of biochar in sustainable agriculture policies.
4. Develop smaller, portable machines for small-scale farmers and high-capacity machines for industrial needs.
5. Collaborate with carbon credit programs to monetize carbon sequestration through biochar production.
6. Diversify raw materials by utilizing underutilized agricultural residues and investing in R&D.
7. Build marketing networks and regional hubs for biochar distribution and machine servicing.
8. Leverage digital platforms for online marketplaces and connecting producers with urban markets.
9. Monitor and evaluate the economic, social and environmental impacts of biochar production.
10. Promote biochar production as a community initiative to enhance inclusivity and rural empowerment.

#### Remarks by Mr. Sumukh K Bhat, Nullwaste Industries Private Limited

Mr. Sumukh K Bhat presented a detailed overview of the innovative work carried out by Nullwaste Industries Private Limited in the field of biomass pyrolysis, bio-oil extraction, and sustainable commercialization. He explained that the company is a Bengaluru-based cleantech enterprise operating at the intersection of biomass waste management, carbon-negative materials, and sustainable chemistry. The organization follows the philosophy that waste is





a design flaw and that agricultural and industrial biomass residues can be transformed into high-value products when processed through scientific and efficient technologies.

Mr. Bhat highlighted that Nullwaste primarily focuses on thermo-chemical conversion of biomass through continuous pyrolysis, with coconut shells serving as the flagship feedstock due to their high lignin content, uniformity, and wide availability across India. Through process innovation, the company has developed a scalable system that produces biochar, bio-oil (wood vinegar), and biogas, ensuring near-zero waste generation and complete value extraction from biomass.

He elaborated on the fundamentals of pyrolysis, describing it as a controlled heating process conducted in the absence of oxygen, which prevents combustion and allows biomass to decompose into solid, liquid, and gaseous fractions. The continuous reactor system operated at approximately 550°C offers advantages such as higher throughput, better thermal efficiency, consistent chemical composition of outputs, and easy integration with downstream processing systems.

Mr. Bhat further explained the advanced multi-stage condensation system used for bio-oil extraction. Hot vapors released during pyrolysis are passed through a three-stage industrial condenser setup, which enables effective fractional recovery of heavy tars, medium-weight organic compounds, and lighter condensable vapors. The condensed liquid is collected in sealed containers and allowed to settle, naturally separating into light, middle, and heavy fractions, with the middle fraction being refined and marketed as wood vinegar.

He discussed the complex chemical composition of coconut shell bio-oil, which contains organic acids, phenolic compounds, carbonyls, alcohols, and trace elements derived from biomass decomposition. This unique composition gives the bio-oil strong antimicrobial, antifungal, and pesticidal properties, making it a multifunctional bio-input rather than a single-purpose product.

Special emphasis was given to the agricultural applications of bio-oil, particularly as an organic fungicide. Mr. Bhat shared results of scientific validations conducted at institutions such as the Central Plantation Crops Research Institute (CPCRI), where the bio-oil showed near-complete inhibition of *Phytophthora palmivora*, a major pathogen affecting plantation crops like arecanut, coconut, coffee, and several horticultural crops. He also noted ongoing trials at IIHR Bengaluru and CCRI Seegodu, along with entomological evaluations demonstrating insecticidal potential.

He highlighted that bio-oil offers a promising organic alternative to Bordeaux mixture, a commonly used copper-based fungicide, which has led to soil contamination and reduced microbial health over long-term use. The bio-oil provides disease control without heavy metal residues and supports sustainable and residue-free farming systems.

Apart from agriculture, Mr. Bhat explained the applications of refined wood vinegar in animal feed preservation, livestock hygiene, and various industrial uses such as wood preservation, chemical feedstocks, and construction additives. He concluded by outlining Nullwaste's commercialization strategy, which focuses on scalable production, problem-solving applications, B2B partnerships, and gradual development of branded refined products.

## Recommendations

1. Promote Scalable Pyrolysis Technologies: Encourage adoption of continuous pyrolysis systems for efficient biomass conversion and consistent product quality.
2. Strengthen Scientific Validation of Bio-Inputs: Support institutional trials and field evaluations to establish bio-oil and biochar as reliable organic alternatives to chemical inputs.
3. Encourage Waste-to-Value Business Models: Promote enterprises that convert agricultural residues into high-value sustainable products to reduce waste and enhance farmer income.
4. Support Commercialization and Market Linkages: Facilitate partnerships between cleantech companies, farmers, and agri-input industries for large-scale adoption of bio-based products.



## Technical Session-2: Innovative Applications for Biochar Utilization

- Chairperson** : Dr. B. N. Patil, Former ADR, UAS, Dharwad  
**Co-Chairperson** : Dr. K. Manjappa, University Head (Agron.), UAS, Dharwad  
**Rapporteurs** : Dr. S. A. Biradar, Professor of Agronomy  
Dr. R. A. Nandagavi, Prog. Co-ordinator, KVK, Bagalakote  
**Speakers** : Dr. Vikas Abrol, Professor (Soil Science), SKUAST-Jammu-180009, J & K  
Dr. Leena V. Hublikar, Asst. Professor (Chemistry), KLE Tech University, Hubballi  
Dr. H. K. Joshi, NAU, Navsari  
P. Ashoka, UAS, Dharwad  
Ms. Gayathri P. K., UAS, Dharwad

### Remarks of Dr. Vikas Abrol

Dr. Vikas Abrol, Professor at J&K Agricultural University, expressed his gratitude to the organizers for the opportunity to present his work and emphasized his passion for biochar research. He shared insights into his journey, which began during his post-doctoral research in Israel in 2014, where he studied the soil and water conservation potential of biochar. Highlighting the issue of crop residue burning in Punjab, he stressed the need to view crop residue as a resource and demonstrated how biochar can transform waste into wealth. Dr. Abrol discussed experiments involving the application of biochar and an anionic polymer in Basmati 370 rice and maize under rainfed conditions. The results revealed improved



water productivity, yield and soil moisture retention due to biochar's porosity and carbon sequestration properties. He observed algal growth in treated plots, indicating carbon accumulation and microbial propagation. Further, he described field experiments comparing the System of Rice Intensification (SRI) with conventional methods, where biochar and polymer combinations reduced water use by 27% while enhancing root growth and water productivity.

Dr. Abrol transitioned to his research on nano biochar, funded by two DST projects worth ₹2 crores. He detailed the development of nitrogen and potassium-loaded nano biochar as hybrid fertilizers, characterized using advanced techniques such as FTIR and surface area analysis. Nano biochar demonstrated significantly higher surface area and pore volume, promoting microbial growth. Experiments on maize under rainfed conditions showed that nitrogen and potassium-loaded nano biochar outperformed inorganic fertilizers, even with a 25% reduction in fertilizer application. Combined nano biochar treatments resulted in better grain yield, harvest index, crop length, girth and rainwater use efficiency, highlighting its potential to enhance productivity in resource-limited environments. Dr. Abrol concluded by emphasizing the transformative impact of biochar and nano biochar in sustainable agriculture.

### Recommendations:

1. Promote the use of biochar as a sustainable solution to mitigate the environmental impact of crop residue burning and transform agricultural waste into a valuable resource.
2. Encourage the adoption of biochar in rainfed agricultural systems to improve water productivity, soil moisture retention and crop yields.



3. Integrate biochar with other conservation practices, such as the System of Rice Intensification (SRI), to reduce water use and enhance root growth and overall crop performance.
4. Invest in the development and application of advanced biochar technologies, such as nitrogen- and potassium-loaded nano biochar, to improve nutrient use efficiency and reduce dependence on inorganic fertilizers.
5. Conduct further research on the efficacy of nano biochar as a hybrid fertilizer, particularly in resource-limited and rainfed environments, to maximize its potential benefits.
6. Promote collaborative research projects and funding opportunities to explore the multifunctional applications of biochar and its nano variants in sustainable agriculture.
7. Create awareness and provide training for farmers on the benefits and practical applications of biochar to facilitate its widespread adoption.
8. Develop policies and incentives to encourage the production and utilization of biochar, thereby supporting carbon sequestration efforts and sustainable farming practices.

### Concluding Remarks by the Chairman – Session on Innovative Applications for Biochar Utilization

The Chairman, Dr. B.N. Patil, summarized the session as an insightful exploration into the innovative uses of biochar in agriculture, water filtration and energy applications. The session featured five speakers who addressed various technical and applied aspects of biochar.

Dr. Vikas Abrol presented research on nanobiochar-based NNK fertilizer in rice and maize systems of the northwestern Himalayas. The discussion emphasized the need for clarity on biochar versus nanobiochar, foliar application feasibility and cost analysis for large-scale application.

Dr. Leena V. Hublikar discussed nanoparticle-fortified biochar, highlighting its advantages in water purification, energy storage and agricultural use.

Dr. H.K. Joshi evaluated *Prosopis juliflora* biochar combined with gypsum and its positive effects on rice and wheat yield in coastal saline soils.

Dr. P. Ashoka presented on sugarcane trash management using biochar and decomposers, with the recommendation to conduct long-term field demonstrations for more robust data.

Ms. Gayathri P.K. emphasized the importance of improving soil nutrient supply and crop growth.

In conclusion, the Chairman recommended that quantification studies on biochar's nutrient content and crop residue potential be undertaken, alongside cost analysis of on-farm biochar production. He further urged the need for long-term evaluations across cropping systems to better understand its agronomic and economic implications.

The session concluded with a vote of thanks to all contributors and participants.

**Theme 3. Carbon Credits and Market Mechanisms** (*Carbon credits and incentivizing; Guidelines and Policy issues; Carbon trading and markets, Trading mechanisms; Networking and discovering new market opportunities, Success stories and lessons learned from agricultural carbon credit projects*)

**Chairman** : **Dr. V. S. Korikantimath**, Former Director, ICAR Central Coastal Agricultural Research Institute, Goa

**Co-Chairman** : **Dr. R. Basavarajappa**, Director of Extension, UAS, Dharwad

**Rapporteurs** : **Dr. P. S. Pattar**, Professor of Agronomy, AC, Dharwad  
**Dr. B. S. Yenagi**, Sr. Scientist & Head, AICRP (Oil seeds)

**Lead Speakers:** **Dr. Ram Swaroop Meena**, Department of Agronomy, Institute of Agricultural Sciences, BHU, Varanasi (UP)

**Dr. Srikanth Vishwanath** (Presenter: **Dr. Priyanka Sathe**), Mash Makes Product Owner: Biochar and Carbon Removal



**Dr. V. C. Patil**, Managing Director Sagaranadu Sattvic Foods LLP Rajankollur, Dt: Yadgir  
**Mr. Ashis Panigrahi**, Carbon Market and Traceability Expert  
**Dr. C. M. Biradar**, CMD, Global Green Growth  
**Dr. Sourabh Munnoli**, UAS, Dharwad  
**Dr. S. N. Bhat**, UAS, Raichur

### Remarks of Dr. Ram Swaroop Meena

Dr. Ram Swaroop Meena, Professor of Agronomy at BHU, Varanasi, expressed his views during the session. Reflecting on the overuse of fertilizers post-Green Revolution and its declining efficiency, he emphasized the rising burden of agrochemical subsidies, biodiversity loss and health hazards such as those linked with "cancer trains" in Punjab. He highlighted the need to restore soil organic carbon (SOC) as a foundation for sustainable agriculture and pointed to biochar as a key component in regenerative farming for improving soil carbon stability, aggregate structure and water retention.

Drawing from his DST funded projects and personal research experience, Dr. Meena emphasized that conventional carbon additions via crop residues or compost often degrade rapidly, offering limited sequestration benefits. In contrast, biochar, depending on pyrolysis conditions, exhibited long-term stability and improved nutrient retention. He also noted India's low carbon conservation index and the urgent need to explore biochar-based carbon credit models in agriculture.

He advocated for a policy shift toward "green carbon credits" that reward practices enhancing SOC, including agroforestry, waste valorization and improved residue management. Dr. Meena suggested the integration of carbon credit schemes with degraded land reclamation and conservation agriculture. He also stressed the need to diversify carbon credit pathways using India's rich agroecosystem diversity.

Dr. Meena concluded by urging reforms in subsidy allocations toward ecosystem service payments, strengthening carbon-based agricultural policy frameworks and adopting a multidisciplinary, integrated research and extension approach to scale carbon farming innovations.



### Recommendations

1. **Develop National Policy on Green Carbon Credits**  
A dedicated framework is needed to incentivize agricultural practices that enhance soil carbon, such as biochar application, conservation tillage and agroforestry.
2. **Promote Biochar Use for Long-Term Carbon Sequestration**  
Encourage the adoption of biochar as a stable carbon sink and soil amendment by validating pyrolysis techniques and linking outputs to carbon markets.
3. **Reform Fertilizer Subsidy Strategy**  
Redirect a portion of fertilizer subsidies toward incentives for ecosystem services, including carbon sequestration and improved soil health.
4. **Integrate Carbon Farming in Degraded Land Reclamation**  
Utilize degraded lands for carbon farming through agroecological models that restore soil organic carbon and expand cultivable areas.
5. **Build Capacity Through Targeted Trainings**  
Establish training programs for farmers and extension workers on carbon credit mechanisms, biochar technology and natural resource management practices.



## Remarks by Dr. Priyanka Sathe, MASH Makes Biochar Fertilizer Department

Dr. Priyanka Sathe, representing MASH Makes, an Indo-Danish venture based in India, elaborated on the company's pioneering work in the production and application of biochar using high-throughput pyrolysis technology. The remarks formed part of the deliberations during the national seminar on integrating biochar production, carbon sequestration and carbon trading for carbon-neutral farming. Dr. Sathe emphasized the dual focus of MASH Makes Biochar: enabling climate mitigation through carbon sequestration and supporting sustainable agriculture through soil amendment using biochar.



MASH Makes currently operates a state of the art biochar production facility in Udupi, Karnataka, where cashew nut shell residues an abundant agro-industrial waste are utilized as a uniform feedstock. Through pyrolysis, the process yields EBC-certified biochar, biofuel and syngas. The resulting biochar has a carbon content exceeding 84%, low polycyclic aromatic hydrocarbons (PAHs) and high porosity, making it suitable for agricultural application and eligible for carbon credits under internationally accepted standards.

Dr. Sathe outlined the company's ambitious vision to sequester one megaton of CO<sub>2</sub> by 2040, scaling operations not only in India but also in Vietnam and South Africa, in alignment with global decarbonization goals. She shared that the biochar produced is already being successfully tested and validated in over 30 field trials on crops such as maize, soybean, chilli and paddy, across varied geographies. The trials have revealed positive effects on crop yield, water-use efficiency, drought tolerance and improvement in soil health.

Despite these promising results, she candidly addressed several challenges impeding large-scale adoption. One primary constraint is the economic affordability for farmers, especially smallholders, due to high input costs and lack of access to financial support. Biochar's bulkiness and difficulty in handling pose logistical problems, further deterring its use. Moreover, she highlighted the low level of awareness among farmers regarding the correct dosage, application methods and benefits of biochar.

To overcome these constraints, MASH Makes has initiated innovative marketing and distribution strategies. These include:

1. Pay-as-you-go models, allowing farmers to pay in installments;
2. Sponsorships from corporate partners as part of their decarbonization efforts (e.g., through CSR or ESG frameworks);
3. Partnerships with universities and Krishi Vigyan Kendras (KVKs) for research, demonstration and capacity building;
4. Collaboration with NGOs and Farmer Producer Organizations (FPOs) to strengthen grassroots adoption and community engagement.

She also suggested that blending biochar with compost or organic fertilizers could provide an effective and low-cost solution to boost adoption while improving agronomic efficiency. This would not only reduce the application rate per acre but also enhance microbial activity and nutrient retention in the soil.

Dr. Sathe concluded by expressing MASH Makes's commitment to evidence-based, farmer-centric biochar solutions that contribute to both climate resilience and farm productivity. She welcomed ideas for cross-sectoral collaborations, scaling deployment through policy support and further scientific validation through on-farm trials and university-led R&D.



## Recommendations

1. Develop Affordable Payment Models: Implement pay-as-you-go, EMI, or micro-credit schemes to reduce financial burden on small and marginal farmers.
2. Strengthen Institutional Collaborations: Engage with NGOs, FPOs, KVKs and agricultural universities for joint extension, field demonstrations and farmer training programs.
3. Promote Biochar-Organic Blends: Introduce pre-mixed or on-farm biochar and compost formulations to improve application efficiency and nutrient synergy.
4. Integrate Biochar into Policy Frameworks: Advocate for policy recognition of biochar as a component in national organic farming schemes and carbon markets.
5. Increase Farmer Awareness through Pilots: Conduct targeted awareness campaigns, provide free trial kits and use model farms to showcase biochar benefits.

## Remarks by Dr. V. C. Patil, Former Dean (PGS), UAS, Raichur

Dr. V.C. Patil, an experienced Agronomist and Biochar practitioner, presented a comprehensive case study based on his on-farm experience with biochar production and application. Speaking from a farmer's perspective, he highlighted the practical challenges of biochar production, particularly the high cost and labor-intensive process of biomass collection, which amounted to around ₹2 to ₹2.5 per kg. He estimated that the total cost of producing one kg of biochar on-farm could be as high as ₹10, requiring a selling price of ₹12–13 for sustainable returns. Mechanization, such as cotton balers costing ₹70–80 lakhs, was deemed essential for biomass collection but unaffordable for individual farmers.



Dr. Patil explained his training and experience in Kon-tiki and soil pit methods. He emphasized the importance of proper quenching to ensure biochar quality and avoid conversion into ash. He discussed the difficulties of meeting carbon credit certification standards (e.g., DMRV protocols), including the need for temperature logs, photos and videos during production, which proved to be technically demanding. He noted the logistical issues of biochar production using pyrolysis units, such as inconsistent electricity supply and limitations of Kuntikis, especially in terms of portability and scalability.



Kon-Tiki kiln method

Further, he explored the economics of using paddy straw as a feedstock, pointing out its low lignin content and high ash content. Despite these challenges, he advocated for its use to reduce field burning and improve soil potassium levels. Dr. Patil also stressed the importance of charging biochar with nutrients or microbial consortia and incubating it to enhance effectiveness. He argued that uncharged biochar held limited value for farmers and called for granulation to improve application efficiency.



Soil Pit Method

He promoted university collaborations for developing branded, biochar-based products tailored for crops like pulses, chickpeas and sugarcane. Highlighting examples from his own practice, he demonstrated how he experimented with charging biochar using gypsum and microbial consortia and how product granulation could solve field application problems.

Finally, Dr. Patil touched on carbon credit verification. He had produced a significant quantity of biochar, but carbon credits were awarded only for the portion applied to soil, limiting his carbon earnings. He had earned 16 carbon credits (equivalent to 11 tonnes of carbon), highlighting the necessity of application-based verification. He called for better support systems to make biochar economically viable and beneficial for both industry and farmers.



## Recommendations

1. Promote Mechanized Biomass Collection: Introduce subsidies or cooperative models to make baling and collection equipment (e.g., cotton balers) accessible to small and medium farmers.
2. Simplify Carbon Credit Protocols: Streamline DMRV certification procedures with farmer-friendly digital tools to reduce documentation burden and technical barriers.
3. Develop and Support Local Biochar Technologies: Encourage R&D on low-cost, efficient and scalable pyrolysis units and soil pit systems suitable for decentralized, rural deployment.
4. Value Addition through Nutrient Enrichment and Granulation: Promote research on nutrient-charged biochar formulations and encourage granulation techniques to improve handling and soil application efficiency.
5. University-Industry-Farmer Collaborations: Foster partnerships for developing branded biochar-based products under university labels to build trust and market reach, especially for region specific crops.

## Remarks by Dr. Chandrashekhar M. Biradar, Founder and CMD, Global Green Growth CoP (GGGC), Bengaluru

Dr. Chandrashekhar M. Biradar delivered an insightful presentation on building climate resilience through regenerative agriculture and the strategic role of soil carbon in driving green economic growth. He highlighted that climate change, land degradation, and rising input costs are placing enormous pressure on global agricultural systems, particularly in India where a large proportion of farming is rainfed and highly vulnerable to climate variability. Conventional agricultural practices, he noted, have significantly depleted soil fertility and contributed to greenhouse gas emissions, making a transition toward regenerative and climate-positive farming systems essential.



Dr. Biradar emphasized that regenerative agriculture, rooted in agroecological principles such as minimal tillage, agroforestry, organic amendments, and nutrient recycling, offers a holistic pathway to restore soil health and ecosystem services. At the center of this approach is soil organic carbon, which improves soil fertility, water-holding capacity, and crop productivity while simultaneously sequestering atmospheric carbon dioxide. He pointed out that Indian soils, particularly in dryland regions, suffer from a carbon deficit of 50–70%, representing both a serious challenge and a major opportunity for climate mitigation and sustainable development.

The role of biochar was highlighted as a cornerstone of regenerative agriculture. Biochar, produced through biomass pyrolysis, is a carbon-rich material that enhances soil structure, increases water retention, improves nutrient efficiency, and stabilizes carbon in soils for hundreds to thousands of years. Dr. Biradar explained that integrating biochar into farming systems can increase soil organic carbon levels by 20–40%, reduce erosion, improve microbial activity, and boost crop yields, especially in rainfed and degraded lands. He also noted that biochar aligns well with circular bioeconomy models by converting agricultural residues into valuable soil inputs.

He further discussed the concept of green water management, particularly in dryland regions. By improving soil's capacity to retain rainwater where it falls, biochar helps reduce runoff, enhance groundwater recharge, and ensure moisture availability during dry spells. This approach, termed in-soil water harvesting, strengthens drought resilience and reduces dependence on external irrigation sources, making farming systems more sustainable under changing climatic conditions.

Dr. Biradar highlighted the emerging economic opportunities linked to soil carbon restoration and biochar-based carbon sequestration. He explained that carbon markets are increasingly recognizing soil carbon and biochar



as high-integrity carbon removal solutions due to their permanence and multiple co-benefits. Farmers can potentially earn additional income through carbon credits while simultaneously improving soil productivity and reducing input costs. This creates stacked value streams that support both environmental sustainability and rural livelihoods.

He also discussed the growing policy support for regenerative agriculture and carbon-smart practices in India, including initiatives related to natural farming, soil health programs, biomass utilization, and the development of the Indian Carbon Market. International trade mechanisms and sustainability standards are further driving demand for climate-positive agricultural products, positioning biochar and soil carbon as strategic assets in the emerging green economy.

Dr. Biradar concluded by stressing that integrating regenerative agriculture, biochar systems, digital monitoring, and carbon markets within a coherent policy framework can transform agriculture from a source of environmental stress into a key solution for climate resilience, food security, and inclusive economic growth.

### Recommendations

1. **Mainstream Regenerative Agriculture Practices:**  
Promote agroecological farming methods combined with soil carbon restoration to enhance productivity and climate resilience.
2. **Integrate Biochar into Soil Health Programs:**  
Support large-scale adoption of biochar through incentives, research, and decentralized production models.
3. **Strengthen Carbon Market Participation for Farmers:**  
Develop simple and cost-effective MRV systems to enable farmer inclusion in soil carbon and biochar-based carbon trading.
4. **Promote Green Water Management in Drylands:**  
Encourage in-soil water harvesting practices to improve drought resilience and sustainable water use

### Remarks by Mr. Ashis Panigrahi, Carbon Market and Biochar Traceability Expert

Mr. Ashis Panigrahi presented an insightful overview on the role of technology in enhancing trust and accountability in biochar-based carbon sequestration initiatives. He emphasized that achieving global climate targets, particularly limiting warming to 1.5°C, requires large-scale carbon dioxide removal alongside emission reduction efforts. Among various mitigation approaches, biochar was highlighted as a promising solution due to its long-term carbon stability, multiple environmental benefits, and suitability for agricultural systems in developing countries like India.

He explained that biochar is produced through the controlled pyrolysis of biomass, converting short-cycle carbon into a stable form capable of remaining in soils for hundreds to thousands of years. In addition to carbon sequestration, biochar improves soil fertility, water retention, and crop productivity. Despite these advantages, Mr. Panigrahi pointed out that biochar-based carbon credits face significant challenges in market recognition, primarily due to gaps in measurement, verification, traceability, and transparency across the value chain.

Mr. Panigrahi discussed the major concerns affecting trust in biochar carbon projects, including limited visibility of biomass sourcing and sustainability, variability in biochar quality arising from inconsistent production





conditions, and weak post-production tracking of biochar application. He noted that inconsistent methodologies for carbon quantification and lifecycle emissions further reduce confidence among regulators and buyers, thereby suppressing the value of high-quality carbon removal credits.

To overcome these challenges, he proposed a comprehensive, technology-driven framework for end-to-end traceability. This included digital data capture at the biomass source using mobile applications and geotagging, real-time monitoring of pyrolysis processes through IoT-based sensors, GPS tracking of transport emissions, and integration of laboratory test results for validating carbon content and stability. He further emphasized the importance of evidence-based verification of biochar application to ensure long-term carbon permanence.

Mr. Panigrahi highlighted blockchain technology as a critical component of this framework, serving as a secure and tamper-proof digital ledger for recording all stages of the biochar lifecycle. Through permissioned access, stakeholders such as producers, independent verifiers, regulators, and carbon credit buyers can interact transparently while ensuring data integrity and auditability. This approach was presented as a means to significantly enhance trust, reduce fraud risks, and improve scalability in carbon markets.

He concluded by stressing that integrating digital traceability systems is essential for unlocking the full potential of biochar in India's emerging carbon market framework. Such innovations would not only strengthen domestic biochar initiatives but also position Indian projects competitively in the global carbon credit market.

### Recommendations

1. Implement End-to-End Digital Monitoring: Promote the use of mobile applications, geotagging, and IoT sensors throughout the biochar production and application process to improve transparency and accuracy in carbon accounting.
2. Strengthen Carbon Measurement and Verification Standards: Establish standardized laboratory testing procedures and lifecycle emission methodologies to enhance credibility of biochar-based carbon credits.
3. Adopt Blockchain-Based Data Management Systems: Integrate blockchain platforms to ensure secure, tamper-proof recording of biochar production, logistics, and end-use information.
4. Support Capacity Building and Technology Adoption: Provide training, financial assistance, and institutional support to farmers and biochar producers for adopting modern digital tools and monitoring technologies.

### Concluding Remarks by the Chairman – Session on Carbon Credits and Market Mechanisms

The third technical session, chaired by Dr. Kori Kanthimath and co-chaired by Dr. R. Basavarajappa, focused on *Carbon Credits and Market Mechanisms* and included eight speakers. Dr. B.S. Yenagi served as the rapporteur alongside Dr. P. S. Pattar.

#### Key recommendations and insights emerged from the presentations:

1. Dr. Ram Swaroop Meena emphasized the vast potential for carbon credits in Indian agriculture, suggesting a focus on health missions, NRM training, subsidies for ecosystem management and incentive payments for eco-intensification.
2. Dr. Priyanka Sathe highlighted the importance of using geographically specific feedstocks for biochar production to ensure economic viability, citing the use of cashew residues in Udupi, Karnataka.
3. Dr. V.C. Patil advocated for the on-farm conversion of agricultural waste into biochar, noting that energy access, water, manpower and skilled labor were critical to scaling such initiatives.
4. From a farmer's perspective, biochar was seen as a tool for reducing water and energy use, improving health and food quality, lowering input costs and enabling carbon credit sales. The case of *Prosopis juliflora* in Gujarat was cited as an example.



5. Dr. Saurabh Mannoli presented results on band application of nitrogen and potassium in sugarcane, which improved resource use efficiency and yields.
6. Dr. S.N. Bhat demonstrated that long-term cropping systems involving pigeon pea and maize–chickpea rotations improved soil carbon stocks in northeastern Karnataka.
7. Mr. Tanmay Taleng showcased the availability of portable to large-scale machinery for biochar production from various farm feedstocks.

The Chairman concluded by expressing appreciation to all presenters and participants, highlighting the practical relevance and future scope of carbon trading mechanisms in agriculture.

**Theme 4. Regenerative and Carbon-Neutral Farming Systems** (*Integrating agroforestry, Conservation Agric, Org.Practices and Leveraging Digital Platform for Climate Resilient Agric.*)

**Chairman :** Dr. B.M.Chittapur, Former DE, UAS, Raichur  
**Co-Chairman:** Dr. H.B.Babalad, Chair Professor, Dr. S.V.Patil Foundation, UASD  
**Rapporteurs :** Dr. C.P.Chandrashekhara, Professor of Agronomy  
**Speakers :** Dr. Santosh Onte, SMS (Agronomy), KVK, Dharwad  
Dr. Hanumant M Halli, ICAR-NIASM, Baramati, Maharashtra  
Mr. Sandeep Sabharwal, Director, Sanga chadvam-Foundation, Hubballi  
Dr. Ramesh Bhat, Editor, Publication Centre, UAS, Dharwad

### **Mr. Remarks by Dr. Hanumanth M. Halli: Restoration of Degraded Lands through Fruit-Based Systems for Carbon Neutrality**

Dr. Hanumanth M. Halli presented a case study from ICAR-NIASM, Baramati, on restoring degraded basaltic lands through fruit-based systems to enhance carbon sequestration and land productivity. He highlighted that agriculture, forestry and land use together contribute around 25% of global GHG emissions, with the agriculture sector alone projected to emit 42% of GHGs by the end of the century, even with climate-smart practices.

To meet India's COP26 pledge of reducing emissions by 45% by 2030 and achieving net-zero by 2070, Dr. Halli emphasized the use of degraded and barren lands (98 million ha in India, of which 20 million ha are rocky, shallow basaltic terrains) as a potential carbon sink. He claimed that perennial fruit trees are better suited for such lands than annual crops due to their long-term carbon sequestration potential and ecosystem services.

He elaborated on a land restoration technology developed at ICAR-NIASM involving proclean ripping, blasting, pit formation and filling with a 1:1:1 mix of native soil, organic manure and black soil, followed by planting mango, pomegranate and coconut. Over eight years, this transformed barren lands into productive ecosystems.

Dr. Halli detailed findings from biomass partitioning, carbon stock estimation and GHG budgeting. Mango systems sequestered the highest carbon (164 t CO<sub>2</sub> eq/ha), followed by pomegranate and coconut, with pomegranate offering early and consistent yields from the second year onward. Fuel use during land preparation emerged as the major GHG source.





### He concluded that:

1. Tree species selection is crucial for maximizing carbon sequestration.
2. Restoration of degraded lands offers a viable strategy for carbon offset and economic gains via carbon credits and oxygen production.
3. The NIASM technology aligns with the national GROW initiative and Green Credit Programme aiming to rehabilitate 26 million ha of degraded land.

The transformation demonstrated both environmental benefits and economic viability, showcasing a scalable model for climate-resilient and carbon-neutral agriculture.

### Remarks of Dr. Sandeep Sabharwal – Promoting Artisanal Biochar for Rural Livelihoods and Carbon Credits

Dr. Sandeep Sabharwal, founder of Snagchandram foundation, Hubballi and an agritech startup based in Rajkot with operations across Gujarat, Rajasthan, Madhya Pradesh and Jharkhand, shared grassroots experiences on artisanal biochar production and its socio-economic and environmental impact. His startup engaged over 4,000 farmers and produced 10,000 MT of biochar within 13 months, generating 21,000 carbon credits through low-cost, village-based operations using *Prosopis juliflora* and *Lantana camara* biomass.

He emphasized the role of Kon-Tiki kilns, training local youth and converting invasive species-dominated lands into productive sites. More than 1,500 hectares of *Prosopis juliflora* infested farmland were cleared in 450+ gram panchayats, with villagers receiving biofertilizer made from activated biochar.

Dr. Sabharwal underlined the value of collaborative models with FPOs, industry partners (like Varaha, Circonomy and Bhumitra) and state governments. His startup worked closely with the MGNREGA scheme, enabling employment and local biomass processing. He advocated for Indian certification standards for biochar production and carbon trading, aligning with global systems like Puro and the Universal Carbon Registry.

In biofertilizer development, his team used cow dung compost and Jeevamrut to activate biochar and observed up to 40% crop yield improvement and 20% reduction in input costs in saline-prone regions like Banaskantha. The team also collaborated with research organizations (e.g., Forecast and Biorac DST) to develop bioenzyme-biochar-PROM combinations as biological alternatives to DAP and urea, aiming to reduce chemical fertilizer dependency.

He concluded with a strong message on the need to make farming a first-choice profession, enhance carbon credit returns to farmers and adopt scalable biochar-based technologies for sustainable agriculture, climate mitigation and rural livelihoods enhancement.





## Remarks by Dr. Ramesh Bhat

Dr. Ramesh Bhat delivered a comprehensive talk on the role of biotechnology in biochar production, carbon sequestration and carbon trading aimed at achieving carbon-neutral farming. Drawing from his editorial experience, he presented a bibliometric analysis of 4,156 global research publications on biochar spanning from 2006 to October 2024, focusing specifically on agricultural applications.

He highlighted the emerging role of microalgae as a promising feedstock for biochar due to its abundance and ease of genetic modification. Through literature review, he underscored how biotechnology aids in enhancing the quality of feedstock, particularly through genome editing to increase lipid content in microalgae, thereby improving its suitability for biochar production.

Dr. Bhat emphasized that biochar research, though in a nascent stage, is growing rapidly, particularly after 2014, driven by its potential in improving soil health, enhancing plant growth and mitigating climate change. He pointed out that biotechnological interventions such as the development of high biomass plants, genetically modified microbes and enrichment of biochar with beneficial microorganisms (e.g., nitrogen-fixing bacteria and phosphate-solubilizing fungi) offer significant promise.

He cited a study by Weijer *et al.* (2015) showing that biochar application led to a notable increase in plant growth parameters (leaf area, root length and rosette diameter) and up regulation of growth-related genes, while concurrently downregulating defense-related genes such as those involved in jasmonic acid synthesis. This revealed a possible trade-off between enhanced growth and reduced plant defense.

Further, he referred to a study by Chang *et al.* (2020), where genetic editing in microalgae increased lipid content by over 270-fold, demonstrating the potential for creating customized, high-energy feedstock for biochar production.

Addressing queries, Dr. Bhat clarified that the focus of his research was not on altering biochar's inert chemical nature, but on improving the quality of the biomass feedstock through biotechnology prior to pyrolysis. He emphasized that while biochar itself remains chemically stable, value addition can occur through post-production microbial enrichment.

His presentation concluded with the view that biotechnology offers vast potential to enhance biochar's role in sustainable agriculture, particularly through customized feedstocks, microbial consortia and genetic engineering tools, paving the way for impactful research and policy action.



## Recommendations

1. Promote biotechnological research on microalgae and high-biomass feedstocks to enhance the efficiency and quality of biochar production.
2. Encourage genetic modification of beneficial microbes (e.g., nitrogen-fixing bacteria, phosphate-solubilizing fungi) for integration into biochar-based soil amendments.
3. Support molecular studies on plant-biochar interactions, particularly on gene expression related to growth promotion and plant defense mechanisms.
4. Adopt bibliometric and data-driven approaches to identify global research trends, collaboration opportunities and future directions in biochar science.



## Remarks by Mr. Niraj, Kheti, Initiation Bihar

Mr. Niraj, representing the agroforestry initiative *Kheti* from Lakshisaraï district, Bihar, shared insights into his ongoing efforts toward ecological farming. He began implementing agroforestry in 2018 on a semi-arid plot surrounded by chemically cultivated fields. Through water channels, life fencing, mulching and a rainhouse irrigation system, the project aimed to simulate natural ecosystems and support biodiversity.

He explained that no exotic crops were introduced; instead, region-specific crops were cultivated in a densified, forest-like design using organic inputs such as cow dung and urine-based preparations. Within 100 days, the plot showed promising signs of crop diversity and land rejuvenation. The project also included a Farmer Agroforestry Fellowship Program to replicate demonstration models across various agro-climatic zones.

He reported that after one year and seven months, the once-degraded land had significantly regenerated. Agroforestry practices had not only improved biodiversity but also addressed water stagnation issues. During heavy rains in August 2020, water percolation and groundwater recharge occurred within a day, contrasting previous flooding issues.

In response to a query, he confirmed that fruit trees like mango, guava and banana had been integrated, though they had only begun fruiting recently due to the farm's young age.

### Recommendations

1. Promote region-specific agroforestry models that integrate native crops and fruit trees to enhance biodiversity and ecological balance on farmers' fields.
2. Adopt natural farming inputs such as cow dung and urine-based concoctions to reduce chemical dependence and support soil regeneration.
3. Implement decentralized demonstration plots and fellowships across diverse agro-climatic zones to replicate successful agroforestry practices and build farmer capacity.
4. Incorporate water management techniques like rainhouse irrigation, trenches and percolation-based systems to improve groundwater recharge and mitigate flood risks.

## Remarks by Dr. Daniel, University of Oslo, Norway

Dr. Daniel, a social scientist from the University of Oslo, expressed deep appreciation for the hospitality extended during the seminar. He noted that, although not a technical expert, he found the two-day interdisciplinary exposure to biochar science and agronomy highly enriching.

He traced his interest in biochar to his academic background in anthropology at the University of Munich, where he studied *terra preta*—ancient Amazonian dark earth. He emphasized that the practice of integrating biochar into soil for long-term fertility has historical roots across various continents, including West Africa and South America.





Dr. Daniel recounted his field experiences in Tamil Nadu and Wayanad (Kerala), where he studied farming communities coping with distress. These communities, he observed, were actively exploring alternatives to Green Revolution agriculture, including natural farming, biodynamics and biochar. He highlighted the potential of smallholder farmers as innovators capable of ground-level experimentation.

Currently involved in a project titled "Anthropogenic Soils", he explained how global communities are restoring polluted and degraded soils through methods such as phytoremediation and micro-remediation. He expressed keen interest in how biochar is being applied in both farm-level and industrial contexts in India.

While acknowledging the promise of biochar, he cautioned that it should not be viewed as a magic bullet. He flagged concerns over potential conflicts between private interests and public good, especially in the context of carbon trading and land use competition for food, feed and fuel. He cited global cases, such as land grabs in West Africa, as a warning.

Dr. Daniel concluded by praising the uniquely inclusive and dynamic biochar ecosystem in India, involving farmers, scientists, startups and institutions. He emphasized that India appeared to be at the forefront of biochar research and hoped to return for future collaborations.

### Concluding Remarks by the Chairman - Technical Session 4

The Chairman summarized the session as wide-ranging and insightful, noting that although the number of initial speakers was limited, several valuable contributors were added later. The session began with Shri Ashish Panigrahi, who emphasized the importance of traceability and institutional collaboration in carbon offsetting initiatives. Dr. V.C. Patil highlighted biochar developments in India, while Mr. Hurley from Baramati discussed soil regeneration through horticulture.

Dr. Ramesh Bhat presented an extensive bibliometric analysis of global biochar research, which was appreciated for its depth and scientific rigor. Ms. Rakshita from ADM offered industrial collaboration for biochar promotion. Mr. Neeraj from Bihar shared on-ground experiences in regenerative farming and Dr. Daniel from Norway provided a global and anthropological perspective on biochar's historical and social relevance. The Chairman appreciated Dr. Daniel's extensive travel and research across India, including regions like Punjab, Kerala and Tamil Nadu. He acknowledged Dr. Daniel's engagement with various farming systems such as biodynamic, organic and natural farming and commended his observations as a social scientist. He expressed gratitude for Dr. Daniel's positive reflections and noted that his insights offered a valuable external perspective on India's agricultural landscape.

The Chairman acknowledged Dr. V.C. Patil for introducing global trends and emphasized that while countries like China lead in biochar literature, India must integrate global knowledge with local innovations. He reflected on previous research at the university, including fly ash, ore tailings and tank silt, urging similar attention toward biochar enrichment for meaningful application.

He stressed that biochar must be managed carefully to avoid excessive carbon dioxide emissions during open burning and should be integrated with existing organic matter management techniques to improve soil health. He concluded by thanking the speakers, delegates and rapporteurs for their contributions and encouraged continued interdisciplinary collaboration in this emerging field.

### Recommendations

1. Recognize and harness the innovative potential of smallholder farmers by supporting grassroots experimentation in sustainable practices like biochar, natural farming and bio-dynamics.
2. Approach biochar expansion cautiously, ensuring it does not conflict with food security or contribute to land grabs, especially in vulnerable or resource-scarce regions.
3. Strengthen interdisciplinary collaborations between social scientists, agronomists, extension agents and policymakers to holistically address soil degradation and community resilience.
4. Promote equitable carbon trading mechanisms that balance private enterprise interests with public good, ensuring biochar remains accessible and beneficial to small and marginal farmers.



## Presidential Remarks by Dr. P. L. Patil, Hon'ble Vice-Chancellor

Dr. P. L. Patil appreciated the successful conduct of the two-day national seminar on biochar, organized by Dr. S. V. Patil Foundation and the University of Agricultural Sciences, Dharwad. He acknowledged the rich deliberations under four thematic sessions and the valuable recommendations drawn by session chairs and rapporteurs.

Although he regretted not being able to attend the full proceedings due to administrative duties, he expressed intent to review the presentations and discussions later. He commended Dr. V. C. Patil for his pioneering work in biochar research, both as a practitioner and promoter of carbon credit initiatives.

### Dr. Patil identified three categories of delegates:

1. Those new to biochar and eager to learn the technology,
2. Researchers already engaged in biochar work,
3. Practitioners sharing field-level experiences.

### He urged the session chairs and rapporteurs to categorize recommendations into two types:

1. Scientific recommendations for guiding future research and
2. Policy recommendations for submission to appropriate authorities for implementation.

He supported the idea of forming a Biochar Working Group or Forum within the Foundation as a precursor to establishing a dedicated Biochar Society, emphasizing the need for more publications and technical maturity.

He concluded by thanking all speakers, delegates and organizers for their contributions to the success of National Seminar.

## Vote of Thanks by Dr. B. N. Aravinda Kumar, Organizing Secretary of National Seminar on Biochar Integration

Dr. B. N. Aravind Kumar extended heartfelt thanks to all dignitaries, speakers, participants and stakeholders for making the national seminar on biochar a grand success. He acknowledged that this was possibly the first national seminar of its kind in India, uniquely combining academia, industry and field practitioners under one platform. He credited the vision of his mentor, Dr. V. C. Patil, for initiating the idea.

The seminar witnessed significant knowledge-sharing from 22 lead papers, 10 oral presentations and 31 posters. Over 200 delegates attended physically, with more than 400 joining online. Dr. Arvind Kumar expressed gratitude to the students and faculty of the Department of Agronomy for their dedicated efforts in organizing the event.





He thanked the Vice-Chancellor Dr. P. L. Patil for his leadership and support, along with other mentors including Dr. M. M. Sheelavanthar, Dr. H. B. Babalad and Dr. P. Chandrasekhar Rao. He acknowledged contributions from industry experts, particularly Dr. N. Sai Bhaskar Reddy, for his demonstration and discussion on biochar production techniques.

Sponsors including NABARD, Watershed Development Department, KVG Bank, Ugar Sugars and UAS Raichur were also thanked for their generous support.

Dr. B.N. Aravinda Kumar noted the sustained interest throughout the two-day event, with full attendance in sessions unlike typical seminars. He highlighted the need to ensure last-mile delivery of biochar benefits to farmers and concluded by wishing all delegates a safe return, carrying with them “sweet biochar memories” and renewed enthusiasm for sustainable agriculture.





**International Organizations Working on Biochar**

Sl. No.	Organization	Address / Location	Country	Focus Area
1	International Biochar Initiative	11130 Sunrise Valley Drive, Suite 350, Reston, Virginia 20191	USA (Global operations)	Global standards, certification, policy advocacy, research networking
2	UK Biochar Research Centre	School of GeoSciences, University of Edinburgh, Edinburgh EH9 3FF	United Kingdom	Biochar science, LCA, agronomy, carbon sequestration
3	Australia New Zealand Biochar Industry Group	Various member institutions, Australia & New Zealand	Australia / NZ	Industry networking, standards, commercialization
4	Japan Biochar Association	Tokyo (operational network)	Japan	Biochar adoption, farmer outreach
5	Korea Biochar Research Center	Gyeongsan, Gyeongbuk Province	South Korea	Biochar R&D, soil applications
6	African Biochar Partnership	Regional network (multiple African nations)	Africa	Soil restoration, smallholder systems
7	Biochar Ontario	Ontario	Canada	Soil carbon, climate mitigation

**National Organizations (India) Working on Biochar**

Sl. No.	Organization	Address	State	Focus Area
1	India Biochar and Bioresources Network	#233, 3rd Floor, 13th Cross, Sadashivanagar,	Karnataka	Biochar promotion, policy, residue valorization
2	Indian Institute of Soil Science	Nabibagh, Berasia Road, Bhopal – 462038	Madhya Pradesh	Soil carbon, biochar research, nutrient dynamics
3	Indian Council of Agricultural Research	Krishi Bhavan, New Delhi – 110001	Delhi	National research coordination, soil health programs
4	Council of Scientific and Industrial Research	Anusandhan Bhavan, 2 Rafi Marg, New Delhi – 110001	Delhi	Biomass conversion, pyrolysis technology
5	Indian Institute of Technology Delhi	Hauz Khas, New Delhi – 110016	Delhi	Bioenergy, biomass pyrolysis research
6	Indian Institute of Technology Kharagpur	Kharagpur – 721302	West Bengal	Biomass valorization, biochar systems
7	University of Agricultural Sciences Raichur	UAS Campus, Lingsugur Road, Raichur-584 104, Karnataka (India)	Karnataka	Biomass conversion, carbon sequestration, biochar research,
8	University of Agricultural Sciences Dharwad	Krishinagar, Dharwad – 580005	Karnataka	Biochar research, carbon sequestration, climate-smart agriculture
9	Progressive Biochar Society	Admn.Office: A -2, Co-operative Industrial Estate Balanagar, Hyderabad – 500 037 India	Telangana	carbon credits and biochar markets. Support for commercialization of biochar

**Indian Corporate / Private Sector Entities Working on Biochar & Carbon Credits**

Sl. No.	Company	Focus Area	Notes
1	Varaha	Biochar CDR projects + Carbon Credits	Climate tech company developing carbon removal from biochar, working with smallholder farmers, generating high-quality carbon credits; signed offtake deals with global buyers (e.g., Microsoft, Google)
2	Biochar India Private Limited (BiocharIND) – Joint initiative by PRESPL, APCChem, and Intellectap	Biochar production + Carbon credit platform	India's planned largest biochar carbon credit platform, producing biochar and ~25,000 tCO <sub>2</sub> e of credits annually
3	Farm2Energy	Biochar supply & biomass solutions	Listed among leading Indian biochar suppliers (biomass feedstock and soil amendment)
4	Anulekh	Biochar manufacturing + carbon initiatives	Biochar supplier positioning products for agriculture and carbon-focused solutions ( <a href="#">HYPERLINK</a> )
5	Sow & Reap Chara Pvt Ltd (partnered with Sagar Cements)	Biochar + gasification technologies	Climate-tech partner deploying biochar units with industrial decarbonization focus (cement plant collaboration)
6	Sanjivani Agro Machinery Ltd.,	Biochar Machinery	Listed among leading Indian pyrolyzer biochar units suppliers
7	Jain Irrigation / Jain Group projects	Industrial biochar production + carbon credits	Initiative planning large-scale biochar facility to produce 25,000 t biochar and ~50,000 carbon credits annually



**International Private Companies & Projects in Biochar & Carbon Credits**

Sl. No.	Company / Project	Focus Area	Notes
1	Exomad Green	Large-scale biochar CDR	One of the world's largest biochar producers generating durable carbon removal credits
2	Novocarbo	Biochar production + carbon removal	Converts plant residues into biochar to sequester CO <sub>2</sub> and generate carbon credits
3	Aperam BioEnergia	Biochar CDR supplier	Brazil-based biochar supplier featured among top carbon removal projects globally
4	Pacific Biochar	Biochar CDR & soil impact	North American biochar project generating carbon credits
5	Carboneers Biochar Project	Decentralized biochar & carbon credits	Project converting waste into biochar while training farmers and generating C-Sink certified credits
6	Green Carbon, Inc.	Biochar project development + carbon credits	Japanese company partnering with Indian manufacturing to develop biochar CDR projects
7	Carbonfuture (partnered with Swiss Re)	Carbon credit off-take & MRV ecosystem	While not purely biochar, it sources biochar carbon removal credits (e.g., from Exomad Green) and trades them in global markets

**Table: Effect of Pyrolysis Temperature on Biochar Properties and Agronomic Implications**

Parameter	Low Temp)	400–500°C (Medium Temp)	500–700°C (High Temp)	>700°C (Very High Temp)	Agronomic / Carbon Implication
Type of Pyrolysis	Slow pyrolysis	Moderate pyrolysis	High-temperature pyrolysis	Advanced thermal treatment	Determines chemical & structural evolution
Fixed Carbon (%)	Moderate (50–65%)	High (65–75%)	Very high (75–85%)	Extremely high (>85%)	-----
Volatile Matter	High	Moderate	Low	Very low	Low temp chars decompose faster
Aromaticity	Low	Moderate	High	Very high	Controls long-term stability
Carbon Stability (Permanence)	10–50 years	50–100 years	100–500+ years	500–1000+ years	Critical for carbon credit eligibility
Surface Area (m <sup>2</sup> /g)	5–50	100–300	300–600+	Very high but fragile	Higher SA → better adsorption
Porosity	Low–Moderate	High	Very High (micropores)	Highly microporous	Influences nutrient & water retention
Functional Groups (–COOH, –OH)	High	Moderate	Low	Very low	Important for CEC & microbial attachment
Cation Exchange Capacity (CEC)	Moderate	High	Moderate	Lower	Medium temp often optimal for soil fertility
pH	7–8	8–9	9–10	10–11	High temp useful for acidic soils
Ash Content	Low	Moderate	High	Very High	Contributes to liming effect
Nitrogen Retention	Higher	Moderate	Low	Very Low	Low temp retains more nutrients
Water Holding Capacity	Moderate	High	High	Variable	Improves WUE
Microbial Habitat Suitability	Very Good	Excellent	Moderate	Limited	Medium temp ideal for microbial enrichment
Best Use Case	Nutrient retention	Balanced soil improvement	Carbon sequestration	Carbon removal credits	Selection depends on objective

**Summary Table: Recommended Temperature Based on Objective**

Objective	Recommended Temperature Range	Reason
Nutrient adsorption & CEC improvement	-----	Retains functional groups
Water holding improvement	400–600°C	Good pore structure
Microbial inoculation carrier	400–550°C	Balanced chemistry & porosity
Long-term carbon sequestration	500–700°C	High aromatic stability
Carbon credit projects (CDR)	-----	Greater permanence & MRV compliance
Soil acidity correction	≥600°C	Higher pH & ash content



### Carbon Market Relevance Table

Temperature	Aromatic Carbon Fraction	Stability Index	Carbon Credit Suitability
<400°C	Low	Low	Limited
400–500°C	Moderate	Moderate	Conditional
500–700°C	High	High	Preferred
>700°C	Very High	Very High	Strong for CDR projects

### Engineered / Modern Pyrolyzers

Sl. No.	Type of Pyrolyzer	Mode of Operation	Scale	Temperature Range (°C)	Key Features	Advantages	Limitations
1	Fixed Bed Reactor	Biomass kept stationary; external heating	Small–Medium	350–600	Simple chamber system	Uniform char; relatively simple design	Batch process; limited scalability
2	Rotary Kiln Reactor	Rotating cylindrical drum; continuous feed	Industrial	400–700	Continuous operation	High throughput; consistent quality	High capital cost
3	Fluidized Bed Reactor	Biomass suspended in hot gas stream	Industrial	450–700	Excellent temperature control	High surface area biochar; efficient heat transfer	Complex design; expensive
4	Screw/Auger Reactor	Biomass conveyed through heated tube by screw	Medium–Large	400–600	Continuous feeding	Compact; good for decentralized plants	Requires mechanical maintenance
5	Microwave Pyrolyzer	Microwave energy heats biomass internally	Research scale	400–700	Rapid heating	Uniform internal heating	High electricity demand
6	Mobile Pyrolysis Unit	Containerized / tractor-mounted system	Field-scale	400–650	On-site residue conversion	Reduces stubble burning; flexible	Moderate cost

### Analysis of crop biochar samples

Biochar Feedstock	C (%)	H (%)	N (%)	S (%)	C/N Ratio	H/C Ratio	Ash (%)	Bulk Density (g/cm <sup>3</sup> )
Cotton	71.10	1.93	1.20	0.26	59.19	0.32	14.0	0.25
Pigeonpea	69.60	1.59	0.77	0.55	83.20	0.27	10.0	0.23
Paddy straw	41.77	1.91	0.87	0.17	48.18	0.54	42.0	0.19

Studies conducted by Dr. V. C. Patil (2024), revealed that the biochars derived from cotton and pigeonpea feedstocks exhibited higher carbon content ( $\approx 70\%$ ) and lower H/C ratios (0.27–0.32), indicating greater aromaticity and stability, making them suitable for long-term carbon sequestration. In contrast, paddy straw biochar showed lower carbon (41.77%) but very high ash content (42%), suggesting higher mineral concentration and potential liming or soil amendment value. The C/N ratios (48–83) indicate that all biochars are relatively stable with slow nitrogen mineralization, with pigeonpea biochar being the most recalcitrant among the three. H/C ratios below 0.40 would be the best.



**Proceedings of National Seminar on  
Integrating Biochar Production, Carbon Sequestration  
and Carbon Trading for a Carbon Neutral Farming**





# Proceedings of National Seminar on Integrating Biochar Production, Carbon Sequestration and Carbon Trading for a Carbon Neutral Farming





**University of Agricultural Sciences, Dharwad, Karnataka**



# BHARAT'S GROWTH PARTNER



Boosting Rural Infrastructure

Driving Rural Innovations

Supporting Livelihoods

Empowering the Grassroot Collectives

Bolstering Rural Financial Institutions

Strengthening Rural Climate Resilience

We are India's apex development bank, established in 1982 under an Act of Parliament to promote sustainable and equitable agriculture and rural development. We continue to transform our villages through our Financial, Developmental, and Supervisory functions.

[www.nabard.org](http://www.nabard.org)

Taking Rural India >> Forward

[YouTube](#) [Facebook](#) [Twitter](#) [Instagram](#) / nabardonline

