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Carbon Sequestration Potential of Pea-Based Cropping Systems

Krishna Kant Kumar[1] and Radheshyam Dhole[2]

Abstract: -

Carbon sequestration in agricultural soils has emerged as a crucial strategy for mitigating climate change while sustaining crop productivity. Pea (Pisum sativum L.), a cool-season grain legume, plays a significant role in enhancing soil organic carbon (SOC) through biological nitrogen fixation, residue incorporation, and improved soil structure. Pea-based cropping systems contribute to climate change mitigation by increasing carbon inputs to soil and reducing dependence on synthetic nitrogen fertilizers. This article reviews the mechanisms of carbon sequestration in pea-based systems, examines agronomic practices that enhance carbon storage, and highlights their role in sustainable agriculture. The findings suggest that integration of pea into diverse cropping systems can significantly improve soil carbon dynamics while ensuring long-term productivity and environmental sustainability etc.

Introduction:

Agricultural soils are both a source and a sink of atmospheric carbon dioxide (CO_2). Unsustainable farming practices have resulted in substantial losses of soil organic carbon, contributing to climate change and soil degradation. In this context, carbon sequestration through improved cropping systems has gained global attention as a viable climate mitigation strategy.

Legume-based cropping systems, particularly those involving pea (*Pisum sativum* L.), have demonstrated considerable potential for enhancing soil carbon storage. Pea is widely cultivated for food, feed, and soil fertility improvement. Its ability to fix atmospheric nitrogen, produce high-quality

Krishna Kant Kumar[1] and Radheshyam Dhole[2]

[1] Research Scholar, Narayan Institute of Agricultural Sciences, Gopal Narayan Singh University, Jamuhar Sasaram, Bihar- 821305

[2]Assistant Professor, Narayan Institute of Agricultural Sciences, Gopal Narayan Singh University, Jamuhar Sasaram, Bihar- 821305

biomass, and integrate efficiently into crop rotations makes it an important component of sustainable farming systems. Understanding the carbon sequestration potential of pea-based cropping systems is essential for developing climate-resilient and environmentally sound agronomic practices.

Concept of Carbon Sequestration in Agriculture

Carbon sequestration refers to the process of capturing and storing atmospheric carbon in long-term reservoirs such as soils and vegetation. In agricultural systems, this primarily occurs through:

- Addition of crop residues and root biomass to soil
- Enhancement of soil organic matter formation
- Reduction in carbon losses through erosion and mineralization

Cropping systems that increase biomass production and improve soil biological activity are particularly effective in sequestering carbon.

Role of Pea in Carbon Sequestration

1. Biological Nitrogen Fixation

Pea forms a symbiotic association with *Rhizobium* bacteria, enabling it to fix atmospheric nitrogen. This process reduces the need for synthetic nitrogen fertilizers, whose production and application contribute significantly to greenhouse gas emissions. Enhanced nitrogen availability also promotes greater biomass production, increasing carbon inputs to soil.

2. Biomass Contribution and Residue Quality

Pea produces substantial above-ground residues and extensive root systems. These residues are rich in nitrogen and decompose more efficiently than cereal residues, contributing to stable soil organic matter formation. Root exudates further stimulate microbial activity, enhancing carbon stabilization in soil aggregates.

3. Improvement in Soil Structure

Pea cultivation improves soil aggregation by increasing microbial activity and organic binding agents. Improved soil structure protects organic carbon from rapid decomposition, thereby increasing its residence time in soil.

Pea-Based Cropping Systems and Carbon Dynamics

1. Pea–Cereal Rotations

Inclusion of pea in cereal-based rotations enhances carbon sequestration by:

- Increasing residue diversity
- Improving nutrient cycling
- Enhancing overall biomass production

Pea–wheat or pea–maize systems often show higher soil organic carbon levels compared to continuous cereal cropping.

2. Pea in Conservation Agriculture

When pea is integrated with conservation agriculture practices such as minimum tillage and residue retention, carbon sequestration is further enhanced. Reduced soil disturbance minimizes carbon losses, while retained residues increase carbon inputs.

3. Intercropping and Cover Cropping

Pea-based intercropping systems improve land-use efficiency and increase total biomass return to soil. As a cover crop, pea protects soil from erosion and adds organic matter during fallow periods, contributing to long-term carbon storage.

Agronomic Practices Enhancing Carbon Sequestration in Pea Systems

- **Residue retention and incorporation** instead of burning or removal
- **Reduced tillage** to minimize soil carbon oxidation
- **Balanced nutrient management** to maximize biomass production
- **Use of biofertilizers** to enhance microbial carbon stabilization
- **Crop diversification** with pea inclusion to improve soil carbon pools

These practices collectively enhance both carbon inputs and carbon retention in soil.

Environmental and Agronomic Benefits

Pea-based cropping systems offer multiple co-benefits beyond carbon sequestration:

- Improved soil fertility and nutrient availability
- Reduced greenhouse gas emissions
- Enhanced water-holding capacity of soil
- Increased system productivity and resilience
- Improved sustainability of intensive farming systems

Challenges and Future Prospects

Despite their potential, adoption of pea-based systems faces challenges such as market limitations, varietal constraints, and lack of awareness among farmers. Future research should focus on:

- Quantifying long-term carbon sequestration rates
- Developing high-biomass, climate-resilient pea varieties
- Integrating pea systems into climate-smart agricultural policies

Strengthening extension services and policy support will be essential to maximize the climate mitigation potential of pea-based cropping systems.

Conclusion

Pea-based cropping systems represent a promising approach for enhancing soil carbon sequestration while maintaining agricultural productivity. Through biological nitrogen fixation, biomass contribution, and improvement in soil structure, pea plays a vital role in increasing soil organic carbon stocks. When combined with sustainable agronomic practices such as conservation agriculture and crop diversification, pea-based systems contribute significantly to climate change mitigation and soil health restoration. Promoting the inclusion of pea in cropping systems can thus support sustainable agriculture and global climate goals.

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