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March 2024
Volume-2 , Issue 3
ISSN: 2584-2471

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Carbon Capture and Utilization: a Path to a Sustainable Future

Nishtha Naudiyal[1], Rashmi[2*], Dr. R. K. Srivastava[3]
[1]Deptt. Of Environmental Science, G.B Pant University of Agriculture & Technology, Pantnagar (263145), Uttarakhand
[2]Deptt. Of Chemistry, G.B Pant University of Agriculture & Technology, Pantnagar (263145), Uttarakhand
[3]Deptt. Of Environmental Science, G.B Pant University of Agriculture & Technology, Pantnagar (263145), Uttarakhand

*Email: rashmicyclo2340@gmail.com

Abstract:
Carbon capture and utilization (CCU) is one of the emerging strategies to combat the alarming escalation of greenhouse gases and to match the net-zero carbon resolution by 2070. The fundamental of the process of CCU involves capturing carbon dioxide (CO2) in various ways viz. pre- and post-combustion capture, oxy-fuel combustion, etc. emitted from industrial processes and preventing its escape into the atmosphere eventually providing economic and environmental benefits. It is not just a technological breakthrough but also a societal revolution to obtain circular carbon economy. Thus, CCU is significant in addressing climate change while encouraging sustainable development.

Introduction

Slightly less than eight years, yes that's the time span required to achieve net-zero emissions by the year 2050 given that all emissions are to be thwarted down to half during this period on a global scale. This task seems like a pie-in-the-sky if we take into account the ever-increasing population and their food-energy demands. This is quite alarming as our planet cruises to match up for the net-zero carbon resolution, satisfying these energy gaps while creating a balanced sustainable approach is very crux of survival for the global communities. For numerous decades, charring fossil fuels for energy has been the impetus to the world's carbon footprint causing escalated levels of greenhouse gases in our atmosphere. Elevated temperatures, harsh weather, and an upsurge in sea level are all manifestations of climate change, which is mostly caused by these emissions. While decarbonization is a dire need of the hour some expedient technologies have shown some silver lining amid the dark ages of carbon emissions. Where worries about environmental sustainability and climate change are at the center of international discussions, the need for creative solutions

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is greater than ever. One such solution to combat reckless carbonization of the environment sustainably is carbon capture. Carbon capture and its utilization (CCU) is a very plausible option in the current given circumstances since complete dependence on non-renewable to renewable resources seems impractical and preposterous to think considering its consequential proportion in energy security.

Carbon capture and its utilization

Carbon capture is the process of nabbing down carbon dioxide (CO_2) emissions from industrial processes or power plants and preventing it from escaping into the atmosphere. The most popular methods for achieving carbon capture include pre- and post-combustion capture, oxy-fuel combustion, enabling impregnable acquisition of CO_2 either prior to or following its creation, consequently mitigating its contribution to the carbon footprint. Emerging in the 1970s and 1980s, the earliest CCU operations situated in Texas were designed to extract CO_2 from natural gas processing facilities. Since then CCU has been adopted by number of countries, including Saudi Arabia, the United Arab Emirates, Norway, Canada, Australia, Brazil, and China in heavy-emitting industries upfront (power, steel, cement, oil and gas, and chemicals).

The importance of CCU in achieving sustainable future lies within its ability to mitigate climate change by reducing emissions, securing our energy needs with relatively pristine energy generation, boosting economy and creating jobs and by judicious the use of fossil fuels in and environmentally friendly manner. It can prove a key tool in curbing carbon footprints of industries that are hard on hand to decarbonize, which can attribute to more flexible and diverse energy provisions in near future. This can be achieved by equipping such industries with CCU units that work in tandem to reduce carbon and generate low carbon energy in return for various purposes. By the virtue of carbon capture it is possible to transform absorbed CO_2 into value-added products which culminates to amelioration of circular economy. Through the cost-competitive electrolysis of water using renewable energy, green hydrogen collected CO_2 can be converted into green urea. The conventional manufacture and import of ammonia and urea can be replaced or enhanced by green urea. Although the magnitude of CO_2 harnessed in food and beverages industries is comparatively less despite that it remains a hopeful field to exploit the captured carbon. An avenue for exploiting CO_2 for building material production through aggregate formation and concrete curing is an untapped potential in developing countries with a substantial market. These applications demand less energy since CO_2 can be infused in a liquid state without any conversion. Furthermore chemicals like methanol and ethanol production from CO_2 at a business scale has advocated a promising move in production of green fuel in many parts of the world. Another CO_2 manipulation route is convert it into polymers and bio-plastics which have multipronged materialization utility such as packaging material, furniture, casings, etc. In order to produce low-carbon oil, North America and other regions have exploited CO_2 based EOR (enhanced oil recovery) that has been running smoothly

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for decades. CO_2-EOR can contribute to residual oil extraction which is economically and environmentally viable for carbon capture projects in association with oil resources. The removal of total dissolved solids (TDS) and the conversion of brine into water are two alternative applications for captured CO_2. Though most desalination plants are financially constrained to avoid CO_2 for desalination, novel methods are currently being researched for the low-cost and effective use of CO_2 in this process.

Intentional reductions in emissions could turn into a major environmental setback from unfortunate CO_2 leaks through storage facilities. To prevent this, stringent regulations are in place and being developed through the selection, administration, and oversight of storage locations. It additionally becomes apparent that the overall leakage risk is low because a large number of the possible storage locations are well-known geological formations that have naturally stored gas and CO_2 for millions of years.
Due to greater global legislative backing for the technology and stricter climate targets, the development of CCU has accelerated significantly in recent years. Although this reliable innovation has been around for decades, there are still financial obstacles. Even if employing the captured carbon as a feedstock for manufacturing could result in revenue there is a need for a higher vantage point to create equilibrium between sustainability and economy with a wise discretion of ethics. These CCU units can consume a fair amount of energy to run which can jeopardize the very idea of their financial viability and at worst keep them non-operational. As the market grows and technologies advance, the cost of CCU will keep shrinking. It is obligatory to evaluate costs in light of broader fiscal benefits.
Although CCU renders sustainability feasible; it also comes at a cost to our industries, especially when it comes down to the adoption of CCU by current emitters. As these industries begin to internalise the negative externality of CO_2 emissions into the atmosphere, which is currently borne by society, the early adoption of CCU implementation will come at some costs. Therefore to dream a sustainable future a holistic approach backed with sound policy through premeditated deployment of economic incentives is quintessential for its success. Owing to the magnitude of CO_2 involved, the CCU have to work in tandem with sequestration to complement and deliver value-added chain constantly without any hassle. Along with this a global carbon credit policy is must to incentivize it and cut down cost.

Conclusion

CCU could navigate through cost impediments and provide a competitive alternative for reaching net-zero targets through vigorous industry engagement, federal support, and creative logistics. Production of chemicals and fuels, and the use of renewable energy sources, in particular, can reduce overall costs while offering a sustainable method for producing value-added goods. CCU is a societal revolution rather than only a breakthrough technology. Climate change presents us with our biggest problem, but it also presents us with our best chance yet for sustainable development. This opportunity can be grabbed to decarbonize various sectors while in pursuit of a sustainable and climate-resilient future through carbon capture as one key aspect.

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New Molecular Breeding strategies for Improving Stress tolerance in Horticultural crops

1-Shubham Kumar--Ph.D. Scholar, Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology-Kanpur, U.P.

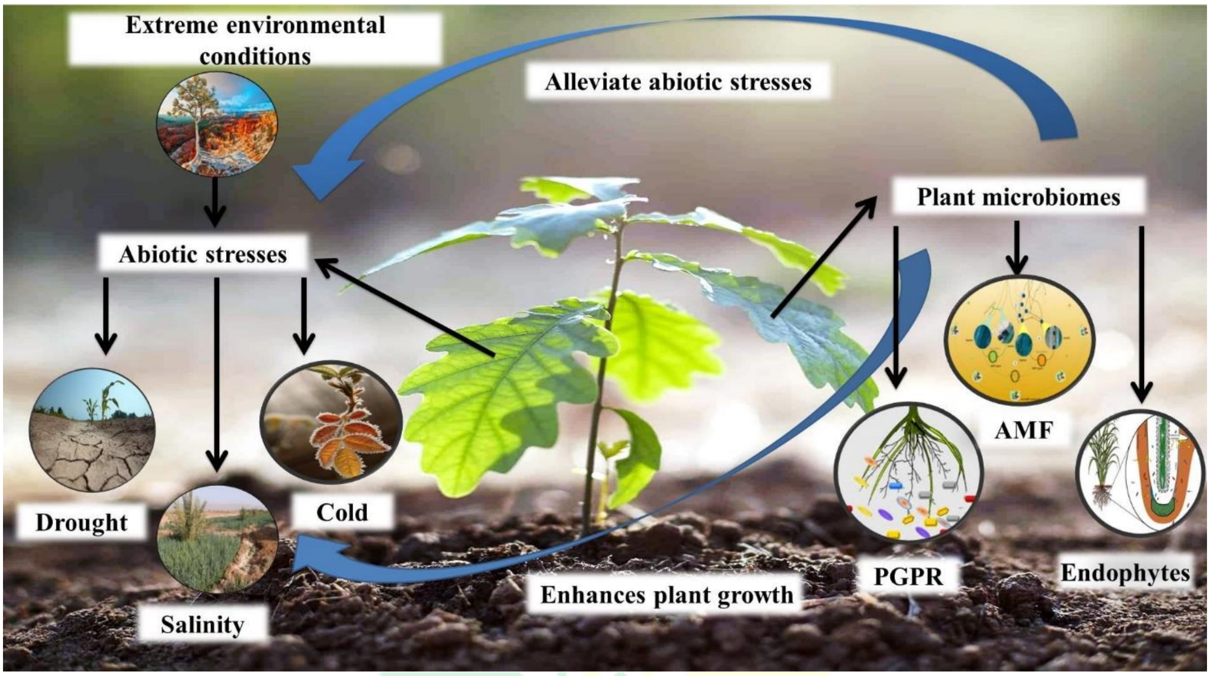
2-Trayambak Gurjar- Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology-Meerut

3-Mayank Tiwari- Ph.D. Scholar, Department of Genetics and Plant Breeding, Govind Ballabh Pant University of Agriculture and Technology (GBPUA&T)- Pantnagar Uttarakhand 263145

Email-shubhamchoudhary3896@gmail.com

Abstract:
Millets, a diverse group of small-seeded grasses, have been a staple food in many parts of the world for thousands of years. Recently, there has been a resurgence of interest in millets due to their exceptional nutritional and health benefits. This review aims to provide an in-depth analysis of the nutritional composition and health-promoting properties of millets. Through an extensive review of the literature, this paper examines the various nutrients present in millets and their potential health benefits, including their role in preventing chronic diseases and promoting overall well-being. Additionally, this review discusses the challenges and opportunities associated with incorporating millets into modern diets. Overall, this review highlights the importance of millets as a nutritious and sustainable food source with significant potential for improving public health.

Introduction: In the face of changing climatic conditions and increasing environmental stresses, ensuring food security is one of the paramount challenges of the 21st century. Horticultural crops, which include fruits, vegetables, ornamental plants, and herbs, are particularly vulnerable to various environmental stresses such as drought, salinity, heat, and pests. However, recent advancements in molecular breeding techniques offer promising avenues for developing stress-tolerant varieties that can withstand adverse conditions while maintaining productivity and quality. In this article, we delve into the innovative molecular breeding strategies revolutionizing the enhancement of stress tolerance in horticultural crops.



Understanding the Challenges: Horticultural crops are exposed to a myriad of stress factors that can significantly hamper their growth, development, and yield. Drought stress, for instance, impairs water uptake and photosynthesis, leading to reduced crop yields and quality. Salinity stress, on the other hand, disrupts ion balance and metabolism, resulting in stunted growth and yield losses. These challenges underscore the urgent need for developing resilient crop varieties capable of thriving under stress conditions.

Molecular Breeding: Traditional breeding methods, although effective, often require years of selective breeding and phenotypic screening to develop stress-tolerant varieties. Molecular breeding, also known as **Molecular-assisted breeding or Marker-assisted selection (MAS),** accelerates the breeding process by leveraging genetic information to identify and introgress desirable traits into elite cultivars. This approach not only expedites the breeding cycle but also enables the precise manipulation of target genes associated with stress tolerance.

Key Molecular Breeding Strategies:

1. **Marker-Assisted Selection (MAS):** MAS involves the identification of molecular markers linked to stress-tolerance traits through genomic analysis. By genotyping individuals at these marker loci, breeders can select plants with the desired traits at early stages of development, thus streamlining the breeding process. For example, in **Tomato** breeding, MAS has been employed to introgress genes conferring **drought tolerance** from wild relatives into cultivated varieties.

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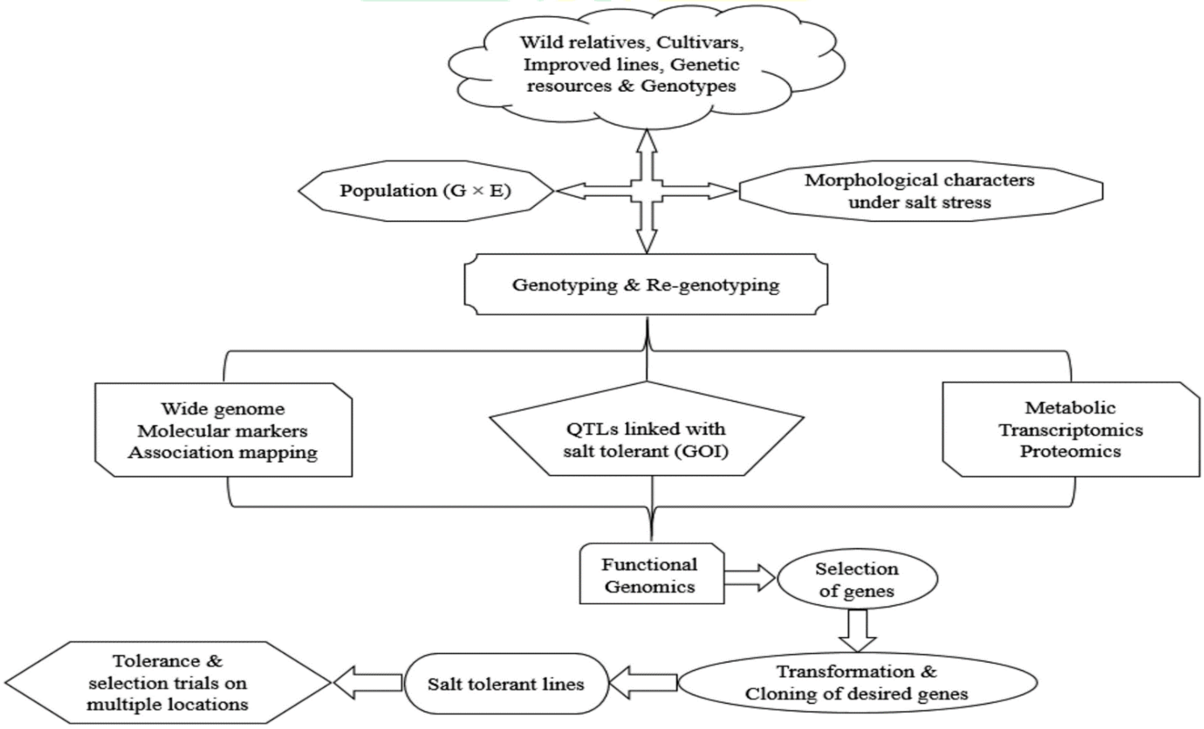
2. **Genomic Selection (GS):** GS integrates high-throughput genotyping and phenotyping data to predict the breeding value of individuals based on their genomic profile. This data-driven approach enables the selection of superior genotypes with enhanced stress tolerance across diverse environments. GS has been particularly effective in perennial horticultural crops such as **Apple and Grapevine**, where breeding cycles are lengthy.

3. **Genome Editing**: Recent advancements in genome editing technologies, notably **CRISPR-Cas9,** offer unprecedented precision in targeted gene manipulation. By precisely modifying key genes involved in stress response pathways, breeders can engineer crops with improved stress tolerance without introducing foreign DNA. Genome editing holds immense potential for enhancing stress resilience in horticultural crops while addressing consumer concerns regarding Genetically modified organisms **(GMOs).**



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4. **Omics-Assisted Breeding**: Omics technologies, including **Genomics, Transcriptomics, Proteomics, and Metabolomics**, provide comprehensive insights into the molecular mechanisms underlying stress tolerance in crops. Integrating omics data with traditional breeding approaches enables the identification of novel genes, regulatory networks, and metabolic pathways associated with stress response. This holistic understanding facilitates the development of tailored breeding strategies for enhancing stress tolerance in horticultural identification of novel genes, regulatory networks, and metabolic pathways associated with stress response. This holistic understanding facilitates the development of tailored breeding strategies for enhancing stress tolerance in horticultural crops.

Case Studies:

1-**Watermelon:** In watermelon breeding, MAS has been employed to introgress genes conferring resistance to **Fusarium wilt**, a devastating soil-borne disease, from wild Watermelon relatives into commercial cultivars. This has led to the development of wilt-resistant varieties with improved yield and fruit quality under disease pressure.

2-**Strawberry:** Genome editing has been utilized to enhance disease resistance and fruit quality traits in Strawberry. By precisely editing genes associated with pathogen susceptibility and fruit ripening, researchers have developed Strawberry varieties with prolonged shelf life and reduced susceptibility to fungal diseases.

Future Perspectives: The ongoing advancements in molecular breeding technologies hold immense promise for addressing the complex challenges posed by environmental stresses in horticultural crop production. Future research endeavors should focus on leveraging emerging tools such as machine learning and artificial intelligence to further optimize breeding strategies and accelerate the development of stress-tolerant crop varieties. Moreover, concerted efforts are needed to ensure equitable access and responsible deployment of molecular breeding technologies to benefit farmers, consumers, and the environment.

Conclusion: The integration of new molecular breeding strategies into horticultural crop improvement programs represents a paradigm shift in agricultural research and development. By harnessing the power of genomics, genome editing, and omics technologies, breeders can expedite the development of stress-tolerant varieties that are essential for ensuring food security and sustainability in the face of evolving environmental challenges.

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The Plight of Indian Farmers: Challenges and Solutions

Yadunandan Verma

Research Scholar, Department of genetics and plant breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, C.G.

Email: vermayadunandan9868@gmail.com

Abstract:
Indian agriculture, long considered the backbone of the nation's economy, faces a multitude of challenges that threaten the livelihoods and well-being of millions of farmers. This abstract explores the pressing issues confronting indian farmers and proposes potential solutions to alleviate their plight. Challenges such as climate change-induced weather extremes, mounting debt burdens, inadequate irrigation facilities, fragmented land holdings, market volatility, and limited access to technology plague Indian farmers. These challenges contribute to a vicious cycle of poverty and despair, pushing many farmers to the brink of desperation. To address these challenges, comprehensive solutions are imperative. Investment in irrigation infrastructure, debt relief measures, consolidation of land holdings, price stabilization mechanisms, promotion of climate-resilient farming practices, and harnessing technology for agriculture emerge as key strategies. These solutions aim to enhance farmers' resilience, improve productivity, and ensure fair remuneration for their produce.

Introduction: Indian agriculture stands as the cornerstone of the nation's economy, employing over half of the country's workforce and providing sustenance for a vast population. Yet, beneath this facade of abundance lies a stark reality – Indian farmers face an array of formidable challenges that threaten their very existence. From adverse weather conditions to crippling debt and systemic neglect, the plight of Indian farmers is a tale of resilience amidst adversity. In this introduction, we delve into the multifaceted challenges that confront Indian farmers, unraveling the complexities of their struggles, and exploring potential pathways towards sustainable solutions. As we navigate through the labyrinth of issues plaguing the agricultural landscape, it becomes evident that the road ahead is fraught with obstacles, yet not devoid of hope.

The challenges facing indian farmers are as diverse as the crops they cultivate. Climate change, with its erratic weather patterns and increasingly frequent extreme events, wreaks havoc on agricultural productivity. Unpredictable rainfall, prolonged droughts, and devastating floods disrupt sowing cycles,

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decimate crops, and push farmers into a perpetual cycle of uncertainty. Compounding these climatic challenges is the specter of mounting debt that looms over Indian farmers. High input costs, coupled with fluctuating crop prices, often leave farmers indebted to moneylenders or trapped in exploitative cycles of borrowing. The burden of debt not only threatens their financial stability but also exacts a heavy toll on their mental well-being, driving many to the brink of despair. Furthermore, the inadequate infrastructure for irrigation exacerbates the vulnerability of Indian farmers, particularly those reliant on rain-fed agriculture. Limited access to reliable water sources constrains crop yields and perpetuates poverty in rural communities. Moreover, the fragmentation of land holdings, a legacy of historical agrarian reforms, undermines the scalability of farming operations, impeding the adoption of modern technologies and best practices. In addition to these structural challenges, Indian farmers grapple with the vagaries of the market, where price fluctuations and middleman exploitation erode their profits and bargaining power. Lack of market access and information further exacerbates their vulnerability, trapping them in a cycle of poverty and dependency. Amidst these myriad challenges, however, glimmers of hope emerge. Across the country, initiatives aimed at empowering farmers, enhancing resilience, and fostering sustainable agriculture are gaining momentum. From government schemes to grassroots innovations, a diverse array of solutions is being explored to address the root causes of farmers' woes and pave the way for a brighter future.

As we embark on this exploration of the plight of Indian farmers, it becomes imperative to heed their voices, understand their struggles, and champion their cause. Only through collective action, informed policymaking, and unwavering commitment can we navigate the labyrinth of challenges and chart a course towards a more equitable and sustainable agricultural future for India.

Challenges Faced by Indian Farmers: Climate Change: Indian farmers are highly vulnerable to the adverse impacts of climate change, including erratic rainfall, droughts, floods, and heatwaves. These unpredictable weather patterns disrupt agricultural activities, leading to crop failures and financial losses. Following given the some challenges which is faced by Indian farmers-

- ✓ **Debt Burden:** Many farmers in India are trapped in a cycle of debt due to high input costs, low crop prices, and limited access to credit. Mounting debts often drive farmers to despair, pushing them towards extreme measures such as suicide.
- ✓ **Lack of Irrigation Facilities:** Despite being predominantly an agrarian economy, a significant portion of Indian farmland still lacks access to reliable irrigation facilities. Dependence on rainfall makes crops vulnerable to droughts, further exacerbating farmers' woes.
- ✓ **Fragmented Land Holdings:** Indian agriculture is characterized by small and fragmented land holdings, making it challenging for farmers to adopt modern farming techniques and achieve economies of scale. Fragmentation also limits their bargaining power in the market.

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- of agricultural commodities, coupled with middlemen exploitation, often leave farmers at the mercy of market forces. Lack of transparent and efficient marketing channels further exacerbates their vulnerability.
- **Lack of Access to Technology and Information:** Many farmers, especially those in remote rural areas, lack access to modern agricultural technologies and information. Limited knowledge about best practices and innovative farming methods hinders their productivity and profitability.

Solutions to Alleviate the Plight of Indian Farmers:

The plight of Indian farmers is a multifaceted issue that requires comprehensive solutions at various levels. Here are several strategies that could help alleviate their challenges:

- **Investment in Irrigation Infrastructure:** Government initiatives to enhance irrigation facilities, such as the construction of dams, canals, and water harvesting structures, are crucial to mitigate the impact of erratic rainfall and ensure water security for farmers.
- **Debt Relief and Financial Assistance:** Implementing debt relief schemes, providing subsidized credit, and promoting financial literacy among farmers can help alleviate their debt burden and improve their financial resilience. Additionally, promoting crop insurance schemes to mitigate risks associated with crop failures due to factors like adverse weather conditions, pests, or diseases.
- **Consolidation of Land Holdings:** Encouraging land consolidation through measures like land pooling and cooperative farming can facilitate the adoption of modern agricultural practices and enhance farmers' productivity and income.
- **Price Stabilization Mechanisms:** The establishment of robust price stabilization mechanisms, including minimum support prices (MSPs) and futures markets, can shield farmers from market volatility and ensure fair remuneration for their produce.
- **Promotion of Climate-Resilient Farming Practices:** Promoting climate-smart agricultural techniques such as agroforestry, crop diversification, and water-efficient irrigation methods can help farmers adapt to changing climatic conditions and mitigate risks associated with climate change.
- **Harnessing Technology for Agriculture:** Expanding access to agricultural extension services, mobile applications and digital platforms can empower farmers with valuable information on weather forecasts, market prices, crop management practices, and financial services. Promoting the adoption of modern agricultural technologies such as drip irrigation, precision farming, and use of genetically modified crops that are pest-resistant or drought-tolerant. This can help improve productivity, reduce input costs, and mitigate environmental risks.

Agricultural Reforms: Implementing effective agricultural reforms to ensure fair prices for agricultural produce, better access to markets, and improved

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- infrastructure for storage and transportation of crops. This could involve revisiting and amending agricultural policies to make them more farmer-friendly.
- **Crop Diversification:** Encouraging farmers to diversify their crops to reduce dependence on traditional crops that may be subject to price volatility. Promoting cultivation of high-value crops, organic farming, and introducing sustainable farming practices can enhance farmers' income and resilience.
- **Extension Services and Training:** Strengthening agricultural extension services to provide farmers with timely information, training, and technical assistance on improved farming practices, market trends, and financial management. This can enhance their capacity to make informed decisions and adapt to changing agricultural dynamics.
- **Investment in Rural Infrastructure:** Investing in rural infrastructure development including roads, irrigation facilities, cold storage, and market linkages to reduce post-harvest losses, improve market access, and enhance value chain efficiency.
- **Empowerment of Women Farmers:** Recognizing and empowering women farmers who play a significant role in agriculture by providing them with equal access to resources, training, and support services. Empowering women in agriculture can contribute to household food security and overall rural development.
- **Promotion of Farmer Producer Organizations (FPOs):** Facilitating the formation and strengthening of Farmer Producer Organizations (FPOs) to enable collective bargaining, better access to inputs and markets, and participation in value-added activities such as processing and marketing.
- **Environmental Conservation:** Encouraging sustainable farming practices that conserve natural resources, promote soil health, and minimize environmental degradation. This includes promoting agroforestry, conservation agriculture, and organic farming methods.
- **Policy Support and Political Will:** Enacting and enforcing policies that prioritize the welfare of farmers, address their concerns, and create an enabling environment for agricultural growth and rural development. Political will and commitment to long-term agricultural reforms are crucial for sustainable transformation of the agricultural sector.

Addressing these key areas comprehensively and holistically, it is possible to mitigate the challenges faced by Indian farmers and promote their economic prosperity and well-being.

Conclusion

The plight of Indian farmers demands urgent attention and concerted efforts from policymakers, stakeholders, and society at large. By addressing the root causes of their challenges and implementing holistic solutions, we can transform the agricultural landscape of India, ensuring sustainable livelihoods and prosperity for millions of farmers across the country.

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Article id: 025

Sugarcane insect pests and their biological control

Saba Tanveer and Rajat Mohan Bhatt
Research scholar, Department of Entomology
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar

Abstract:
Sugarcane (Saccharum spp., L) holds significant importance as a cash and industrial crop in numerous tropical and subtropical regions. It serves as a renewable agricultural resource, offering sugar, biofuel, fiber, fertilizer, and various by-products, contributing to ecological sustainability. Globally, around 1300 insect pest species are known to affect sugarcane crops, with 220 species identified as pests in India alone. Throughout its growth stages, sugarcane faces challenges from various insect pests, which significantly impact yield potential. Heavy infestations of these pests have led to substantial reductions in cane yield (up to 86.00%) and sugar recovery (1.4-1.8%). Implementing biological control agents emerges as the most suitable and environmentally friendly management approach, aiming to minimize ecosystem disturbance. Many predators and parasitoids were reported playing significant role in pest regulation in sugarcane agro-ecosystem.

Introduction

Sugarcane is the old sugar source for mankind since years with Brazil as the leading producer of the sugarcane in the world followed by India with a production of about 373 Million tonnes all around the country. It is native to tropical region of South Asia. Sugarcane in India, is considered as one of the major industrial crop which is cultivated under diverse group of climatic conditions. It is a long-lasting monoculture crop of about 12 to 18 months grown on large tracts of land on a commercial scale thus it has been subjected to many abiotic and biotic stresses and among them insect pest causes huge losses. The crop is liable to insect pest damage from planting till harvest and every bit of the cane, from top to root, is attacked by one or the other species.

Pest	Order: Family	Scientific name
I. Borers		
Early shoot borer	Lepidoptera: Crambidae	*Chilo infuscatellus* Snellen
Internode borer	Lepidoptera: Crambidae	*Chilo sacchariphagus indicus* (Kapur)
Top borer	Lepidoptera: Crambidae	*Scirpophaga excerptalis*
Stalk borer	Lepidoptera: Crambidae	*Chilo auricilius* Dudgeon

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Root borer	Lepidoptera: Crambidae	*Polyocha depressella* (Swinhoe)
Gurdaspur borer	Lepidoptera: Crambidae	*Acigona steniellus* (Hampson)
Plassey borer	Lepidoptera: Crambidae	*Chilo tumidicostalis* Hampson
II. Sucking pests		
Pyrilla	Hemiptera: Lophopidae	*Pyrilla perpusilla* Walker
Woolly aphid	Hemiptera: Aphididae	*Ceratovacuna lanigera* Zehntner
Whiteflies	Hemiptera: Aleyrodidae	*Aleurolobus barodensis* Maskell
Scale insect	Hemiptera: Diaspididae	*Melanaspis glomerate* Green
Pink mealy bug	Hemiptera: Pseudococcidae	*Saccharicoccus sacchari* (Cockerell)
III. Subterranean pests		
Termite	Isoptera: Termitidae	*Odontotermes obesus* (Rambur), Microtermes obesi Holmgr
White grub	Coleoptera: Scarabaeidae	*Holotrichia serrata* Fabricius, *Holotrichia consanguinea* Blanchard

In the past years, insect control was attempted according to the situation and has been treated with insecticides a lot more. But contrary to expectation the results have not been spectacular against most of the insect species especially lepidopteran insects This has diverted the attention of the entomologists towards biological control of the insect pests in sugarcane also. Low pesticide usage, occurrence of natural enemies, active participation of governmental agencies and sugar industry make biological control an implementable reality in sugarcane.

Biological control of sugarcane pests in India is a meaningful method in the light of the commercial nature of the crop, which offers advantage like a less disturbed system, continuous availability of the hosts for the natural enemies, restricted use of pesticides, environmentally sound etc. Natural enemies including predators and parasitoids (indigenous or exotic) these are reared in the biocontrol laboratories and supplied to the farmers for release in the crop fields to control specific pests. Spectacular performance of *Isotima javensis* in the control of sugarcane top borer, *Scirpophaga excerptalis* in Tamil Nadu and later in Karnataka is one of the earlier records of biological control in India in sugarcane history.

PARASITOIDS

A large variety of parasitoids deposit eggs on or inside the bodies of their insect hosts, which the developing larvae subsequently consume as food. Trichogrammatids, Ichneumonids, Scleonids, Evanids, Chalcids, and Tachinids are the most significant parasitoid groups that parasitize the eggs of the host insects.

Egg Parasitoid

Trichogrammatids

Trichogramma sp. are amongst the most important and widely used parasitoids of

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sugarcane borers in India. *Trichogramma chilonis*, strain HTTS, developed at NBAII, is tolerant to high temperature (32-40°C). Therefore it can be used efficiently by farmers in higher temperature regions. Once emerged, these parasitoids would parasitize eggs of most lepidopteran pests, such as sugarcane borers, cotton bollworms, corn borers, rice stem borer, leaf folder etc.

Larval Pupal Parasitoids

Ichneumonids

lsotima javensis is an ecto-parasitoid of *S. excerptalis* attacking the larvae and pupae of the pest commonly occurring in North Indian belt. The parasitoid flourishes well during July to September when top borer activity is at its peak.

Braconids

Cotesia Falvipes a gregarious, larval endoparasitoid native to south east Asia parasitizes pyrallid stalk borers in the genus Chilo. Recommended releases of *Cotesia flavipes* @ 2500 gravid females / ha as per ICAR-SBI, Coimbatore.

Tachinids

Tachnid flies an important family of parasitoid insects which are most frequently and effectively used against sugarcane insect pests in India as well as in different countries. Two species mainly *Diatraeophaga striatalis* and *Sturmiopsis inferens* have been reported from Asia

Sturmiopsis inferens

S. inferens has been the subject of extensive research in India, and field releases of the parasitoid in some regions of the nation have had some success. In Tamil Nadu, 20 to 50 gravid females released per hectare from 45 to 75 days after planting. A female is capable of parasitizing 150 to 300 larvae.

Pupal Parasitoid

Tetrastichus howardi a pupal parasitoid of borers including *C. infuscatellus* and *C. sacchariphagus indicus*

Nymphal/Adult Parasitoid

Epiricania melanoleuca is a nymphal/adult parasitoid of pyrilla belonging to the family lepidopterans causing natural parasitisation as high as 69-94%. The epidemic of Pyrilla in Bihar and Uttar Pradesh was suppressed

Pests	Parasitoids	Predators
Early shoot Borer	*Trichogramma sp* *Cotesia flaveps*	Spider
Top borer		Reduviid bug
Internode borer		Preying Mantid
Stalk borer		
Whitefly	*Encarsia Formosa, Eretmocerus sp. Chrysocharis Pentheus*	Mirid bug Lacewing Ladybird beetle
Scales/Mealy bugs	*Encaersia sp. Coccophagus lecanii*	Ladybird beetle Lacewing
Pyrilla	*Epiricania melanoleuca*	
White grub	Entomopathogenic Nematodes	
(AESA based IPM- sugarcane)		

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due to the development of *E. melanoleuca* in September and October, 1973

Conclusion

The habitat of semi-perennial sugarcane encourages biological control and offers a favorable setting for practical biological management. Maintaining the natural biological control element by avoiding system disruption should be the first and foremost goal of biological management of sugarcane pests. Excessive use of pesticides against endemic pests, such as top borer in the subtropics and white grub in the tropics, is likely to convert sugarcane pest management from the natural/applied biological control mode to insecticide mode and sugarcane from an insurance crop to a catastrophic crop.

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The India Rice Trade: Dynamics, Challenges, and Prospects

Abhishek Singh, Amisha Singh Kushvaha

Institute of Agriculture and Natural Sciences, Department of Agricultural Economics, Deen Dayal Upadhyay Gorakhpur University Gorakhpur, Uttar Pradesh

Corresponding Author: abhisheksingh123gkp@gmail.com

Abstract:
India, renowned for its rich agricultural heritage, stands as a global leader in rice production and trade. This abstract delves into the multifaceted landscape of India's rice trade, exploring its dynamics, challenges, and prospects. As a dominant player in both Basmati and non-Basmati rice varieties, India's export trends shape global rice markets. However, challenges such as quality compliance, infrastructure limitations, and price volatility pose significant hurdles. Despite these challenges, growth opportunities abound, including market diversification, technological innovation, and sustainable practices. By addressing these challenges and capitalizing on emerging opportunities, India can fortify its position as a key player in the global rice trade, fostering sustainable development and economic prosperity.

Introduction:

Rice, often referred to as the "staple of staples," holds a central position in India's agricultural tapestry and cultural heritage. As the second-largest producer of rice globally, India's contribution to the global rice trade is profound, shaping not only its economy but also impacting food security and market dynamics worldwide. The Indian rice trade epitomizes a nexus of tradition, innovation, and resilience, navigating through a myriad of challenges while embracing emerging opportunities.

India, known as the land of rice, boasts a rich agricultural heritage deeply intertwined with the cultivation and trade of this staple grain. As one of the world's largest producers and consumers of rice, India's rice trade dynamics are of immense significance both domestically and globally. In this article, we explore the multifaceted landscape of the Indian rice trade, analyzing its dynamics, challenges, and prospects.

1. Dominance in Production:

India is a global powerhouse in rice production, blessed with diverse agro-climatic conditions conducive to rice cultivation. States like West Bengal, Punjab, Uttar Pradesh, and Andhra Pradesh contribute significantly to the country's rice

https://krishiujala.in/
March 2024
Volume-2 , Issue 3
ISSN: 2584-2471

output. Varieties such as Basmati and non-basmati rice from India enjoy widespread recognition for their aroma, flavor, and quality.

2. Export Trends:

a. Basmati Rice:

India's Basmati rice holds a prestigious position in the international market, renowned for its long grains and distinctive fragrance. Key export destinations include the Middle East, Europe, and North America, where Basmati rice is favoured for its premium quality.

b. Non-Basmati Rice:

Non-Basmati rice varieties also constitute a substantial portion of India's rice exports. Countries in Africa, Southeast Asia, and neighbouring regions are major importers of Indian non-Basmati rice, drawn to its affordability and versatility.

3. Challenges in India's Rice Trade:

a. Quality Compliance:

Ensuring compliance with international quality standards and sanitary and phytosanitary regulations remains challenging for Indian rice exporters. Strict adherence to quality parameters is essential to maintain market competitiveness and consumer trust.

b. Infrastructure Constraints:

Inadequate infrastructure, including storage facilities, transportation networks, and port capacity, poses logistical challenges in the export process. Investment in modernizing infrastructure is crucial to streamline supply chains and reduce trade costs.

c. Price Volatility:

Fluctuations in global rice prices, coupled with domestic production variability and currency exchange rates, contribute to price volatility in India's rice trade. Exporters must adopt strategies to mitigate risks and ensure price stability.

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4. Future Prospects:

a. Diversification of Markets:

Expanding market access and diversifying export destinations beyond traditional markets could enhance India's resilience to market fluctuations and geopolitical risks. Strengthening trade ties with emerging economies presents new growth opportunities.

b. Technological Innovation:

Embracing technology-driven solutions, such as precision agriculture, digital platforms for trade facilitation, and value-added processing techniques, can enhance productivity, quality, and competitiveness in India's rice sector.

c. Sustainable Practices:

Promoting sustainable farming practices, including water-efficient cultivation methods, organic farming, and agroecological approaches, is imperative for ensuring the long-term viability of India's rice trade and environmental conservation

Conclusion:

The Indian rice trade stands at a crossroads, poised for transformation amidst evolving market dynamics and global challenges. By addressing infrastructure constraints, quality compliance issues, and embracing innovation and sustainability, India can unlock new avenues for growth and reinforce its position as a leading player in the global rice trade arena. With concerted efforts from stakeholders across the value chain, India's rice sector can chart a path towards sustainable and inclusive development, benefiting farmers, consumers, and the economy at large.