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Indian Farming

भाकृअनुप
ICAR

बेटी बचाओ
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KVKs 1974-2024
कृषि विज्ञान केन्द्र
Krishi Vigyan Kendra
Serving Farmers

GOLDEN JUBILEE OF KRISHI VIGYAN KENDRAS (KVKs)

https://epubs.icar.org.in

Farmers meet at KVK Sirsa

Demonstration on spraying by drone

Vocational-training on bee-keeping by KVK Sangrur

Krishi Vigyan Kendras

Krishi Vigyan Kendras (KVKs) are agricultural extension centres established by the Indian Council of Agricultural Research (ICAR) in India. KVKs serve as knowledge and resource centres in agricultural technology dissemination, aimed at improving the livelihoods of farmers by bridging the gap between researchers and farmers.

The primary objective of KVKs is to provide agricultural extension services to farmers, including training, demonstration, and frontline advisory services, to enhance agricultural productivity and income. KVKs undertake various activities such as conducting on-farm trials, organizing training programs for farmers and extension personnel, demonstrating improved agricultural technologies, providing advisory services, and organizing field days and exhibitions. KVKs play a crucial role in transferring agricultural technologies developed by research institutions to farmers' fields. They serve as hubs for disseminating knowledge on modern agricultural practices and technologies. KVKs collaborate with various stakeholders including agricultural universities, research institutions, government departments, NGOs, and local communities to maximize their outreach and impact.

KVKs also focus on capacity building of extension personnel, agripreneurs, rural youth and women in agriculture through skill development and training programs.

Overall, Krishi Vigyan Kendras play a vital role in empowering farmers with knowledge and resources to adopt sustainable and modern agricultural practices, thereby contributing to agricultural development and rural livelihood improvement in India.

Exposure visit of farmers to RRS Bathinda by KVK Sangrur

Kisan Goshthi at KVK Kullu

Farmers visit to KVK

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Cover I: Agri-drone demonstration by KVK

Cover IV: Future of Food and Agri-culture

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Indian Farming

In This Issue

The Guest Editors of this Special Issue of Indian Farming were:
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MESSAGE

I am happy to know that the Division of Agricultural Extension, ICAR is bringing out a special issue of the *Indian Farming* on the occasion of Golden Jubilee Celebrations of Krishi Vigyan Kendras (KVKs). The Indian Council of Agricultural Research (ICAR) established the first Krishi Vigyan Kendra (KVK) in 1974 at Puducherry (the then Pondicherry). The KVKs are working as frontline extension institutions at the district level across the country, and has evolved its mandate over time. Initially, the mandate of KVK was to provide need-based skill-oriented vocational training to the farmers, farm women, rural youth, and field extension functionaries in agriculture and allied areas. Now KVK will function as a Single Window Agricultural Knowledge, Resource, and Capacity Development Centre to address the forthcoming challenges in agriculture. The KVK system plays a pivotal role in the transfer of agriculture technologies to the farmers while supporting initiatives of public, private and voluntary sectors for improving the agricultural scenario in our country.

In fact, KVKs being involved in the process of increasing the production and productivity of various crops, thereby facilitating in bridging the gap between technology generation at the research institutions and its transfer to the farmers' fields. All KVKs are envisaged to reduce the time-lag between generation of technology at the research institution and its application to the location-specific farmer fields for increasing production, productivity and net farm income on a sustained basis. Besides, KVKs are doing a great work towards the welfare of the farming community in bringing food, nutrition and livelihood security to them.

Documenting the myriad activities undertaken by KVKs is crucial for advancing sustainable agricultural technologies. As strong frontline extension systems, KVKs play a pivotal role in transforming farming practices by promoting the adoption of new technologies to enhance crop yield and quality, reduce costs, and drudgery in production. Moreover, they also sensitize farmers to explore new market opportunities, foster local entrepreneurship, and developing the skills of farmers. KVKs are the sole institutions at the district level in India for technological backstopping in agriculture and allied sectors. KVKs make all the efforts for effective documentation and dissemination of agricultural technologies and work towards amplifying their impact and contributing to the sustainable development of Indian agriculture.

I extend my heartfelt congratulations to the entire team of the Division of Agricultural Extension, ICAR, and the 11 Agricultural Technology Application Research Institutes (ATARIs) for their comprehensive coverage of significant events and activities of KVKs in this special issue of *Indian Farming*. KVKs operate through collaborative efforts among scientists, extension functionaries, and farmers, and their role in improving the socio-economic status and overall quality of life for farmers is commendable. My heartfelt wish is for the KVK system to continue propelling our agriculture sector towards new horizons.

(Himanshu Pathak)

5th March, 2024
New Delhi

EDITORIAL

A Glorious 50 Years Journey of Krishi Vigyan Kendras

As we commemorate the Golden Jubilee of Krishi Vigyan Kendras (KVKs), it is imperative to reflect on their remarkable journey and the invaluable contributions they have made to Indian agriculture. KVKs have emerged as pivotal institutions in transforming the landscape of Indian agriculture since the inception of the first KVK in Puducherry (the then Pondicherry) on 21st March 1974, following Dr Mohan Singh Mehta Committee Report recommendations. Ensuring sustainable food production and household nutritional security on a national scale hinge on the effective diffusion of agricultural innovations. This necessitates sustainable, economically viable, and intensive farming across diverse resource endowments. Farmers need access to technology in crop, livestock, forestry, and fisheries sectors. The Indian Council of Agricultural Research (ICAR) addresses this through KVKs established at district levels across India.

Over the past five decades, the ICAR has built a robust network of 731 KVKs across India, adapting to evolving farming challenges. Accordingly, the mandated activities of KVKs have also changed over the period. The KVKs have been established by the ICAR under the administrative control of Agricultural Universities, ICAR Institutes, State Governments, Public Sector Undertakings (PSUs), Non-Government Organizations (NGOs), Educational Institutions and other organizations emphasizing technology development, adoption, and human resource development to enhance productivity sustainably. The KVKs serve as crucial links between research and extension system, conducting on-farm testing, frontline demonstrations, and training for farmers and extension personnel besides providing feedback to research system and further propelling it to the main extension system. KVKs also serve as knowledge and resource centres for agricultural technologies, uniquely positioned to provide district-level technological support to farmers and stakeholders, with ongoing efforts to strengthen their role.

KVKs have been instrumental in promoting cutting-edge agricultural technologies and sharing knowledge to farmers across the country. Through frontline demonstrations, training programs, and farmer-centric initiatives, KVKs have empowered millions of farmers with the latest advancements in crop production, animal husbandry, agroforestry, and allied sectors. By fostering a culture of innovation and experimentation, KVKs have played a pivotal role in enhancing farm productivity, promoting sustainable practices, and improving rural livelihoods.

One of the most significant achievements of KVKs has been their role in promoting agripreneurship and rural entrepreneurship. By providing training and handholding support to aspiring farmers and rural youth, KVKs have nurtured a new generation of agripreneurs who are driving innovation and economic growth in rural areas. From value-added agri-processing to agri-tourism and niche farming enterprises, KVKs have been at the forefront of fostering a vibrant ecosystem of rural entrepreneurship.

Moreover, KVKs have been catalysts for social empowerment and inclusive development in rural communities. By empowering women farmers, tribal communities, and marginalized groups with relevant skills and knowledge, KVKs have promoted gender equality, social inclusion, and community resilience. Through initiatives such as women's self-help groups, farmer producer organizations, and community-driven extension programmes, KVKs have fostered a sense of ownership and collective action among rural stakeholders.

As we celebrate the Golden Jubilee Year of KVKs, it is essential to recognize the challenges that lie ahead and chart a course for the future. In an era of rapid technological advancements and climate change, KVKs must continue to evolve and adapt to meet the evolving needs of Indian agriculture. Strengthening linkages with research institutions, leveraging digital technologies, and promoting climate-smart agriculture will be crucial in ensuring the resilience and sustainability of Indian agriculture.

This Special Issue encompasses a diverse array of articles delving into crucial facets of resource management, integrated pest management (IPM), ecosystem dynamics under stress, women's empowerment, livelihood diversification, precision agriculture, and the transformative realm of digital agriculture. It is expected that this issue of *Indian Farming* will be very informative and useful to farmers, extension functionaries, and farm entrepreneurs.

Editors

Indian Farming 74 (03): 05-08; March 2024

Krishi Vigyan Kendras

Glorious Journey of Five Decades

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This article offers an insightful exploration into the evolution and transformative impact of Krishi Vigyan Kendras (KVKs) over the past fifty years. The article delves into the pivotal role of KVKs as frontline extension systems in India's agricultural landscape. It traces the inception of KVKs in 1974 and highlights their remarkable growth, with 731 KVKs currently operating across the country. The article outlines the diverse mandates of KVKs, from training and frontline demonstrations to technology assessment and capacity development, reflecting their evolution into comprehensive agricultural knowledge and resource centres. Through an analysis of significant achievements, including the adoption of innovative initiatives like Cluster Frontline Demonstrations and District Agriculture Contingency Plans, the article emphasizes the substantial impact of KVKs on enhancing agricultural productivity, sustainability, and farmers' livelihoods. Furthermore, the article highlights the challenges faced by KVKs, including workforce constraints and administrative issues, calling for concerted efforts to address these challenges and strengthen the capacity of KVKs. In conclusion, the article asserts the pivotal role of KVKs in driving inclusive and resilient agricultural development and underscores the need for sustained support and innovation to ensure their continued success in the future.

Keywords: Achievement, Agricultural Knowledge, Centre, Extension, KVK, Schemes

KRISHI Vigyan Kendras (KVKs) - Agricultural Science Centres, have played a pivotal role as frontline extension systems in India's agricultural landscape. These district-level institutions have been instrumental in shaping the trajectory of Indian agriculture, driving innovation, and empowering farmers with scientific knowledge and techniques. Their journey began with the establishment of the first KVK in Puducherry (formerly Pondicherry) on March 21, 1974 by the Indian Council of Agricultural Research (ICAR) following Dr Mohan Singh Mehta Committee Report recommendations. Since then, KVKs have played a pivotal role in transforming agricultural practices and fostering innovation across the country. The Planning Commission, keeping in view the demand of people from various corners to establish more KVKs in the country had approved scheme of ICAR to establish 44 new KVKs during the Sixth Plan. Further, the National Commission on Agriculture (1976) in its report on 'Research, Education and Extension' recommended that there should be a plan for each district to have one KVK and ultimately to have three for each district.

Cultivation of high value crops in protected condition

India currently boasts a robust network of 731 KVKs operating across the country, with one KVK in 545 districts and two KVKs in 93 districts. This extensive network ensures widespread coverage and accessibility, enabling KVKs to effectively serve the farming communities

Cultivation of saplings, Belagavi

Distribution of saplings, Belagavi

in diverse regions across India. These KVKs, nurtured by ICAR (under the guidance of Agricultural Extension Division), operate under the administrative control of Agricultural Universities (509 KVKs), ICAR Institutes (66 KVKs), Non-Government Organizations (101 KVKs), State Governments (38 KVKs), Central Universities (3 KVKs), Deemed Universities (7 KVKs), Public Sector Undertakings (2 KVKs), and other Educational Institutions (5 KVKs). At zonal level, Agricultural Technology Application Research Institutes (ATARIs) play the role of coordination and monitoring with headquarters at Ludhiana, Jodhpur, Kanpur, Patna, Kolkata, Guwahati, Barapani, Pune, Jabalpur, Hyderabad and Bengaluru.

Transformation of KVKs

The recommendations of several committees and 12 National Conferences of KVKs during last five decades suggested for strengthening of KVKs to meet the changing needs of the Indian farmers. In this period, the KVK has been transformed from mere a training institution to Single Window Agricultural Knowledge, Resource and Capacity Development Centre. Initially, the sole mandate of KVK was to impart training to farmers/farm women/rural youth and extension personnel to enhance their knowledge and skill in the frontier areas of agriculture. During the course of implementation of the KVK scheme, it was realized that training only would not be useful unless it is followed up with frontline demonstrations in farmers' fields in order to demonstrate the production potential of agricultural technologies. Accordingly, frontline demonstration on important crops of the district was added to the mandate of the KVK. Later on, during VIII Five-Year Plan, the mandate of KVK was further reviewed and On-Farm Testing for identifying technologies in terms of location specific land use systems was added to the mandate of the KVK. Further during XI Plan, the mandate of working as resource and knowledge centre of agricultural technologies for supporting initiatives of public, private and voluntary sectors for improving the agricultural economy of the district was also included as activity of the KVK. The mandate of KVKs was technology assessment, refinement and demonstration of technologies/ products in XII Plan and technology assessment and demonstration for its application and capacity development in XIII plan. Now, the proposed mandate of KVK is Single Window Agricultural Knowledge, Resource and Capacity Development Centre.

Significant achievements

The KVKs have played a crucial role in empowering the farmers and proved their worth in addressing the needs of the stakeholders by showcasing the frontier technologies, capacity development of stakeholders, front runner in technology application, making available technological information and inputs, practicing participatory approaches in planning, implementing, executing and evaluation, pursuing assessment and refinement of technologies to suit different agro-climatic conditions.

Over the past five years, numerous farmers affiliated with KVKs have been honoured by the Government of India with Padma Shri Awards and Genome Saviour Award among others, acknowledging their exceptional contributions to agriculture. This recognition underscores the pivotal role played by KVKs in motivating agricultural talent and fostering innovation within farming communities.

The Indian agricultural landscape has witnessed significant transformations through various initiatives taken by KVK aimed at enhancing productivity, ensuring sustainability, and improving farmers' livelihoods. Among these initiatives, the Cluster Frontline Demonstration (CFLD) program has played a crucial role in bolstering pulses production, elevating it from an average of 17.70 MT to 27.80 MT in 2022-23. Concurrently, efforts focused on doubling farmers' income through farm-based interventions have yielded promising results, with 75,000 cases documented and analysed. Furthermore, the implementation of District Agriculture Contingency Plans across 623 districts has provided a comprehensive framework for managing weather aberrations, offering vital support to both line departments and the farming community. Additionally, Crop Residue Management (CRM) initiatives in 60 districts of four states have led to a remarkable 52% reduction in crop residue burning

incidents, contributing significantly to environmental sustainability. Moreover, the scaling of Integrated Farming Systems (IFS) models across 26 States/UTs, including 31 bankable IFS for 22 States, has not only increased household net income by 39% but also improved dietary diversity scores by 8.57%. These achievements underscore the concerted efforts towards holistic agricultural development and underline the commitment to improving the lives of farmers while fostering environmental stewardship.

The third-party evaluation conducted by NITI Aayog Institute - National Institute of Labour Economics Research and Development (2018) sheds light on the significant impact and operational dynamics of KVKs across India. On an average, each KVK covers 43 villages and serves approximately 4,300 farmers, with approximately 80% of these villages located over 10 kilometres away its premises. Notably, off-campus activities outweigh on-campus engagements, emphasizing the KVKs' proactive outreach efforts. Impressively, 96% of farmers' requests are attended to by KVKs, demonstrating their responsiveness to farmers' needs. The adoption of KVK-recommended technologies has led to a notable 42% increase in productivity, while the resultant enhanced incomes are often directed towards improving education, healthcare, and housing. Moreover, each KVK annually trains about 100 individuals in agripreneurship, with approximately 25% of trainees embarking on self-employment ventures thereafter. KVKs also reported a competitive advantage over other organizations providing technology services.

The impact study conducted by the International Food Policy Research Institute (IFPRI) in 2019 highlights the significant contributions of KVKs to agricultural development in India. It reveals that KVK interventions have resulted in an additional net farm income of ₹5752 per hectare, demonstrating their effectiveness in enhancing farmers' livelihoods. Moreover, the study indicates a remarkably high rate of return on expenditure invested in KVKs, with one year of incremental gain covering approximately 12 years of expenditure. Additionally, the Benefit Cost Ratio for expenditure on KVKs is reported to be 11.78, underlining the favourable economic returns generated by KVK initiatives. These findings underscore the substantial impact and cost-effectiveness of KVKs in promoting agricultural productivity and income generation among farmers across the country.

Other schemes and new initiatives

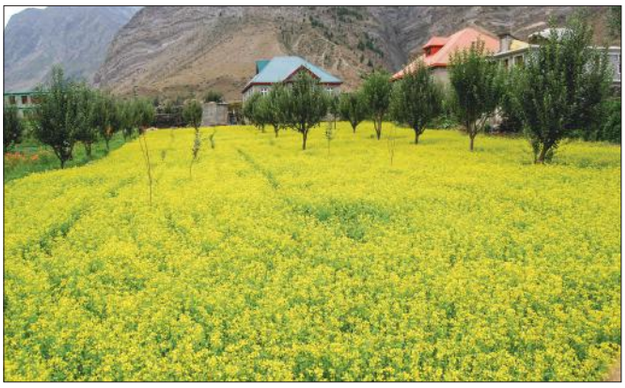
KVKs are actively implementing several impactful schemes aimed at enhancing agricultural practices and empowering communities. Among these, ARYA (Attracting and Retaining Youth in Agriculture) is being implemented across 100 KVKs. An appreciable effort has been made which could result to develop capacity of 65,661 youths, and translating their skills in establishing 14,878 enterprises and ensuring retention of youth in agriculture. Similarly, KSHAMTA (Knowledge Systems and Homestead Agriculture Management in Tribal Areas) covering 125 tribal districts have materialize in conducting 26,800 demonstrations and could train 200,000 tribal farmers. This has helped in promoting sustainable livelihoods, and conserving the indigenous knowledge systems. Considering the role of women in agriculture, NARI (Nutri-sensitive Agricultural Resources and Innovations) project is being implemented with the help of diverse stakeholders to influence sustainability of food and nutritional dynamics by empowering women in agriculture.

Looking at the importance of sustainable agriculture, 425 KVKs have been instrumental in promoting natural farming by organizing 6,777 awareness programs engaging 6.80 lakh farmers, conducting 4,105 demonstrations, and developing the capacity of 37,978 farmers through 418 training programs. KVKs have also spearheaded various initiatives to revolutionize agriculture, including Kisan Sarathi, a digital platform with over 1.74 million registered farmers and more than 5.8 crore advisories sent, and KISAAN 2.0, which integrates over 300 agricultural Apps into a single interface accessible in multiple Indian languages.

KVKs embraced drone technology to modernize farming practices and providing the exposure to students through Atal Tinkering Labs. Additionally, initiatives like Landscape Diagnostic Survey (LDS) in pulses across 52 districts and the promotion of FPOs, with KVKs supporting 117 FPOs and functioning as Cluster-

Organic cultivation of cabbage

KVK Jalandhar



Large scale adoption of toria as second crop

FLD on toria

Based Business Organizations (CBBOs), signify their holistic approach towards agricultural development. The KVKs are building partnership and collaborating with 61 ICAR Institutes, 31 Ministries/departments of Government of India, and private players, like Amazon, Bayer and Krishi Jagran which underscore their commitment to innovation and convergence. Linkages with Common Service Centre (CSC) is going to be the game changer in transmitting agricultural information and making farmers aware about new technologies and schemes. These schemes collectively demonstrate KVKs' commitment to fostering innovation, empowering communities, and ensuring the sustainability of agricultural practices across diverse landscapes.

Issues of KVKs

KVKs face a myriad of challenges that require attention to bolster their efficiency and effectiveness. Initially allocated with a sanctioned strength of 22 personnel, the current workforce has dwindled to just 16 individuals. Concurrently, the scope of mandated activities has expanded significantly, and expectations of diverse stakeholders has also increased manifold to address the current agricultural challenges. Moreover, crunch of human resources (vacant positions) at the KVK level exacerbate its strain, impeding their ability to function optimally. Further, lack of uniformity and various administrative and financial issues related to KVK personnel across the host organisations is impacting their performance. Considering the role of decentralized decision making in excelling extension activities at the KVK level, the need is being felt to delegate the matching authority to KVK Heads across the host organizations. Despite possessing qualifications equivalent to academic faculty members at State Agricultural Universities (SAUs) and ICAR Scientists, SMSs in KVKs also need equitable acknowledgment and recognition. Therefore, the host organisations have greater role to play in addressing such issues for the betterment of KVK system.

CONCLUSION

The establishment of KVKs by the ICAR was an important institutional innovation, marking a significant milestone in the last five decades. The remarkable growth in their numbers, currently standing at 731 across the country, underscores the importance of these centres in fostering agricultural development. KVKs play a crucial role in the assessment and dissemination of agricultural technology, earning widespread appreciation for their impactful contributions. Notably, no other agricultural system in the country, be it large or small, boasts a decentralized research capacity as robust as the frontline initiatives undertaken by KVKs at the district level. These Farm Science Centres serve as dynamic hubs for research, extension, and capacity building, facilitating the seamless transfer of cutting-edge agricultural technologies to farmers. The district-level presence of KVKs ensures that the benefits of research and innovation reach at the grassroots level, and directly impacting local farming communities.

The KVK model has indeed emerged as a beacon of success in agricultural development. However, as we confront new challenges, it becomes imperative to pivot our focus towards the conservation of natural resources, achieving higher agricultural productivity sustainably, and enhancing farmers' income by optimizing the farming-to-market value chain efficiency. In this evolving landscape, KVKs need to strengthen its efforts not only in transforming agriculture, but also ensuring economic sustainability, and accelerating future agricultural growth. By emphasizing the conservation of natural resources, such as water and soil, KVKs can promote sustainable agricultural practices that mitigate environmental degradation while ensuring long-term productivity. Furthermore, by leveraging innovative technologies and best practices, KVKs can facilitate the adoption of methods that enhance productivity without compromising sustainability. This includes promoting precision farming techniques, organic/ natural farming, and integrated pest management strategies tailored to local conditions. By embracing a holistic approach that balances productivity with sustainability and income generation, KVKs can continue to serve as engines of change, driving inclusive and resilient agricultural development in the years to come. However, the issues and challenges being faced by the KVKs needs immediate attention from various level so as to strengthen their capacity and decision-making process while achieving the diverse tasks expected from them.

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Empowering farmers

A comprehensive guide to KVK Portal of ICAR

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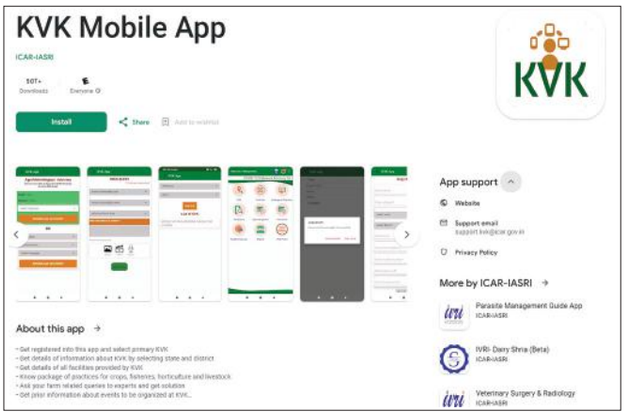
This article delves into the transformative role of Krishi Vigyan Kendras (KVKs), operating under the aegis of Indian Council of Agricultural Research (ICAR), in elevating the socio-economic status of farmers across India. As integral component of the National Agricultural Research System (NARS), KVKs serve as dynamic knowledge and resource centres, focused on the assessment, refinement, and dissemination of location-specific agricultural technologies. The Krishi Vigyan Kendra (KVK) portal, developed by the ICAR, designed to provide farmers with a plethora of resources and services stands out as a beacon of innovation. Through on-farm demonstrations, technology assessments, and capacity-building programme, KVKs facilitate to empower farmers with the latest advancements in agriculture. The collaborative efforts of KVKs with public, private, and voluntary sectors underscore their comprehensive approach to improve the agricultural economy at the district level. The current arcticle explores the multifaceted functions of KVKs, emphasizing their pivotal role in connecting research initiatives with the extension system and farmers. Moreover, this arcticle serves as a comprehensive exploration of how KVKs, as catalysts for agricultural innovation, contribute to the holistic betterment of farmers and the sustainable development of Indian agriculture.

Keywords: Extension, Farmer, Knowledge hub, Portal

IN an era, where technology plays a pivotal role in transforming traditional practices, the Krishi Vigyan Kendra (KVK) portal, developed by the Indian Council of Agricultural Research (ICAR), stands out as a beacon of innovation. This online platform, accessible at https://kvk.icar.gov.in/, is designed to provide farmers with a plethora of resources and services aimed at enhancing agricultural productivity and promoting sustainable farming practices. Krishi Vigyan Kendra (KVK) plays a pivotal role in the agricultural landscape of India, serving as a knowledge and resource hub for farmers. Under the aegis of the ICAR, these centres are instrumental in disseminating advanced agricultural technologies, providing hands-on training, and conducting on-farm demonstrations. This article delves into the significance, functions, and impact of Krishi Vigyan Kendra's in the context of Indian agriculture.

Snapshot of the KVK portal

Krishi Vigyan Kendra Knowledge Network portal (http://kvk.icar.gov.in/) provides basic information of KVKs, facilities of KVKs, district agricultural contingency plan, upcoming, ongoing and past events organized by KVKs, package of practices, access to agro-meteorological advisory and agricultural commodity market prices to farming community. The portal facilitates KVKs to update and upload all types of information so that the related information and knowledge can reach to the farming community in time. A KVK Mobile App for farmers has also been developed for Android users and is available for download in Google Play Store. Farmers need to register and select primary KVK in the App for accessing information. Farmers can ask any farm-related query to the experts of KVKs for solution.



Snapshot of the KVK app

Key features: KVK (ICAR) Portal and KVK App

Knowledge Repository: The portal serves as a centralized hub for a vast repository of agricultural knowledge. Farmers can access a wide range of information related to crop cultivation, pest management, soil health, and more. Best package of practices are readily available to assist farmers in making informed decisions.

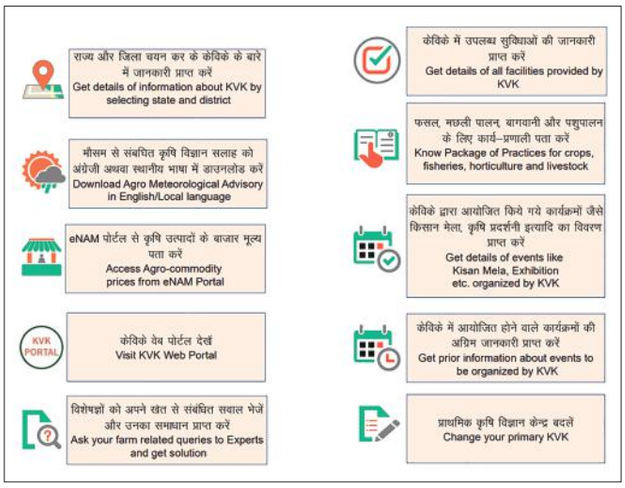
Technology dissemination: KVK (ICAR) Portal acts as a bridge between farmers and cutting-edge agricultural technologies. It disseminates information about the latest advancements in farming techniques, crop varieties, machinery etc. Farmers can stay updated on modern farming practices and adopt techniques that can significantly improve yield and reduce input costs.

Market information: Real-time market information is crucial for farmers to make informed decisions about selling their produce. The portal provides agro-commodity market prices.This feature empowers farmers to negotiate better prices and strategize their crop production based on market demand.

Weather updates and advisory: Weather plays a crucial role in agriculture. The portal offers timely weather updates and forecasts, helping farmers plan their activities more effectively. Advisory services related to weather patterns, crop selection, and timing of agricultural operations are provided to mitigate the impact of adverse weather conditions.

Events' information: The KVK (ICAR) portal provide diverse agricultural events information, including training programme, webinars, exhibitions, field days, awareness campaigns, interactive sessions, etc. These events aim to empower farmers with knowledge, showcase innovations, and foster collaboration, contributing to the sustainable development of agriculture in India.

Query resolution: Farmer can ask their farm related queries along with images, audio, video to the experts of the KVKs and get resolutions for the same. Farmers can seek advice, share experiences, and collaborate with peers, fostering a sense of community and collective learning and many more.



User interface of the KVK app

Background

Established by the ICAR, Krishi Vigyan Kendras are district-level agricultural science centres, created with the primary objective of bridging the gap between scientific research and on-field agricultural practices. The first KVK was set up in 1974 in Puducherry, and since then, their number has grown substantially across the country. The KVK scheme is 100% financed by Govt. of India; and the KVKs are sanctioned to central/ state Agricultural Universities, ICAR institutes, related Government Departments and Non-Government Organizations (NGOs) working in Agriculture sector.

Distribution of KVKs under different institutions is given below:

Central/State Agricultural Universities	509
ICAR Institutes	66
NGOs	101
State Governments	38
Other Educational Institutions	17
Total	**731**

KVKs, being an integral part of the National Agricultural Research System (NARS), aims at assessment of location-specific technology modules in agriculture and allied enterprises, through technology

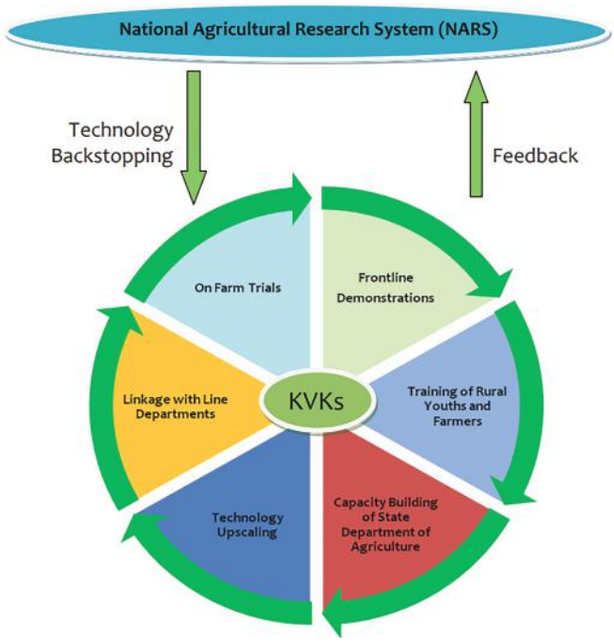
assessment, refinement and demonstrations. KVKs have been functioning as Knowledge and Resource Centre of agricultural technology supporting initiatives of public, private and voluntary sector for improving the agricultural economy of the district and are linking the NARS with extension system and farmers.

ATARI (ICAR)

ATARI stands for Agricultural Technology Application Research Institute, and it is a crucial component of the ICAR. ATARI plays a pivotal role in coordinating and facilitating the application of agricultural technologies developed by various research institutions under the ICAR across different agro-ecological regions. ATARI stands as a key institution dedicated to ensure that cutting-edge agricultural research translates into tangible benefits for farmers across diverse regions in India. Through its multifaceted functions, ATARIs play a pivotal role in shaping the future of agriculture by fostering innovation, promoting sustainability, and improving the livelihoods of farming communities.

Integral part of the National Agricultural Research System (NARS)

Krishi Vigyan Kendras are indeed an integral part of the NARS in India. The NARS comprises of various agricultural research institutions and organizations working collaboratively to address the diverse challenges faced by the agricultural sector. KVKs serve as the practical arm of NARS, ensuring that the outcomes of agricultural research are effectively communicated, demonstrated, and implemented at the grassroots level.



KVK - Integral part of the NARS

Major activities under KVK

Krishi Vigyan Kendras (KVKs) engage in a wide range of activities aimed at enhancing agricultural productivity, promoting sustainable farming practices, and empowering farmers with the latest knowledge and technologies. The specific activities of KVKs can vary, but they typically include on-farm demonstrations, training programme, frontline extension services, seed production and distribution, soil health management, livestock and fisheries development, agro-processing and value-addition, exposure visits, farmers' fair and melas, research and innovation, women empowerment, natural resource management, etc.

These activities collectively contribute to the overall goal of KVKs, which is to improve the livelihoods of farmers, enhance agricultural sustainability, and facilitate the adoption of modern and efficient farming practices in the respective regions they serve.

Mandate and activities of KVK

The mandate of KVK is technology assessment and demonstration for its application and capacity development.

To implement the mandate effectively, the following activities are envisaged for each KVK:

- On-farm testing to assess the location specificity of agricultural technologies under various farming systems.
- Organize frontline demonstrations to establish production potential of technologies on the farmers' fields.
- Capacity development of farmers and extension personnel to update their knowledge and skills on modern agricultural technologies.
- To work as knowledge and resource centre of agricultural technologies for supporting initiatives of public, private and voluntary sector in improving the agricultural economy of the district.
- Provide farm advisories using ICT and other media means on varied subjects of interest to farmers.

In addition, KVKs produce quality technological products (seed, planting material, bio-agents, livestock, fingerlings, etc.) and make it available to farmers, organize frontline extension activities, identify and document selected farm innovations and converge with ongoing schemes and programs within the mandate of KVK.

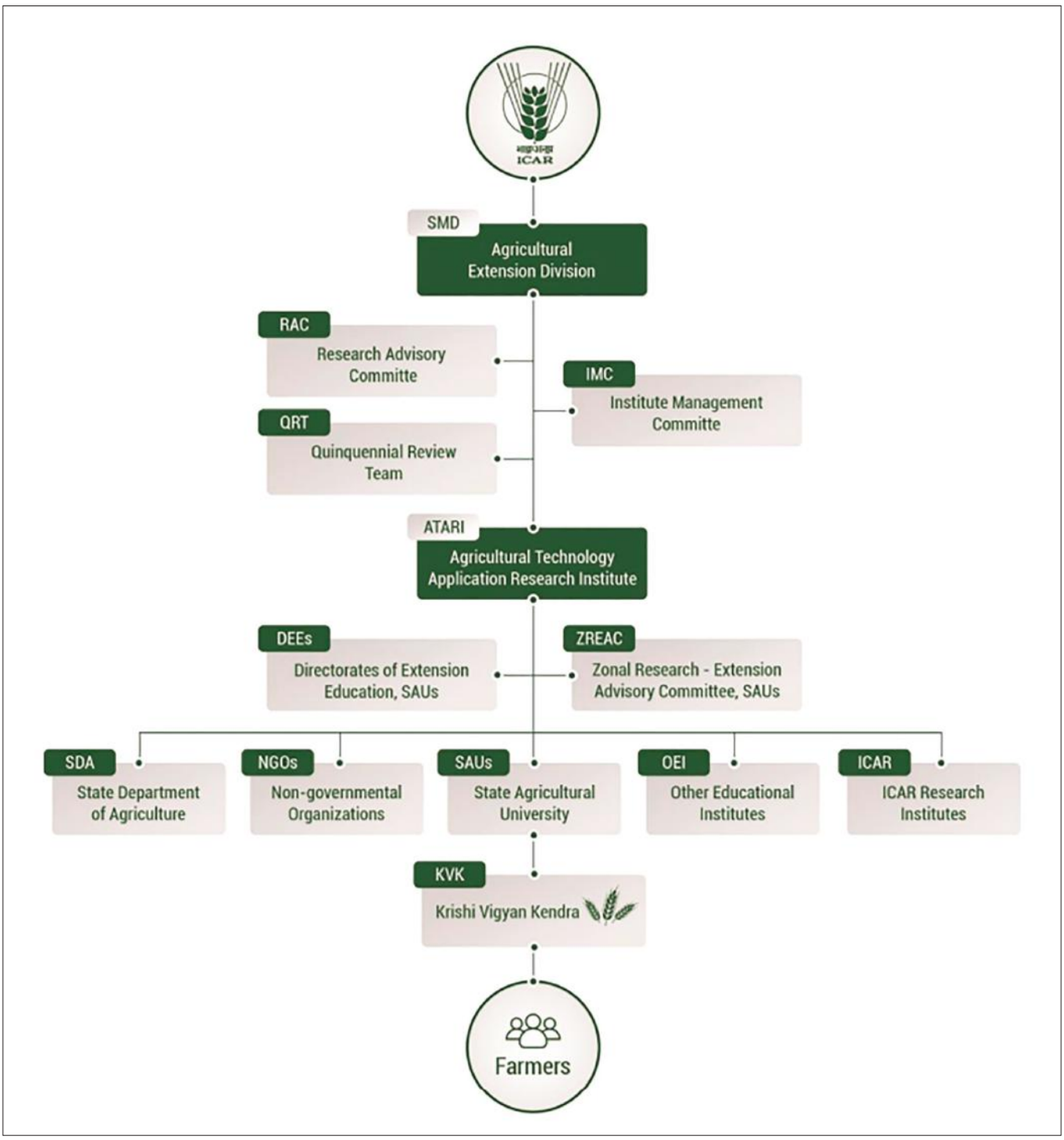
Benefits of KVK portal for farmers

Enhanced productivity: Access to a wealth of agricultural knowledge and technologies empowers farmers to adopt best practices, leading to increased productivity and yield.

Cost reduction: By staying informed about the latest agricultural technologies and market trends, farmers can optimize input costs and improve overall profitability.

Risk mitigation: Timely weather updates and advisory services help farmers anticipate and mitigate risks associated with weather fluctuations, pests, and diseases.

Market access: Market information enables farmers to make strategic decisions about crop selection and



Organizational chart

production volume, ensuring better access to markets and improved bargaining power.

Community building: The interactive forums on the portal foster a sense of community among farmers, encouraging collaboration, knowledge sharing, and collective problem-solving.

SUMMARY

Krishi Vigyan Kendras play a vital role in transforming Indian agriculture by acting as a bridge between research and field-level implementation. Through their multifaceted activities, KVKs contribute to the sustainable development of agriculture, empower farmers, and ensure food security. As India progresses on its agricultural journey, the role of Krishi Vigyan Kendras remains indispensable in shaping a resilient and progressive agricultural sector. The KVK (ICAR) Portal emerges as a transformative tool in the hands of farmers, bridging the gap between traditional agricultural practices and modern technology-driven approaches. By providing access to knowledge, technology, and a supportive community, the portal plays a pivotal role in empowering farmers and contributing to the sustainable development of agriculture in India.

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Surface seeding-cum-mulching technique

An emerging option to manage crop residue

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Surface seeding cum mulching of wheat is an emerging low-cost ecofriendly technique of managing paddy straw, where paddy harvesting and wheat sowing are done simultaneously. Compared to existing residue managemental options, this method has benefits with respect to weed control, soil health as well as crop productivity along with economic benefits as costly machines and high-power tractors are not required in this technique. Straw management and sowing operation of wheat can be completed with a meagre cost of ₹650-700 only compared to ₹2000-2500 per acre for conventional methods. This technique provides complete mulching, which keeps the soil profile moist and saves the crop from terminal heat stress. Moreover, crop resist to lodging as well as withstand against adverse conditions like torrential rain and hailstorms. Besides, this technique reduces dependence on costly herbicide inputs as it ensures mostly weed free crop.

Keywords: Crop residue, Mulching, Surface seeding, Wheat

THE Punjab, Haryana and Western Uttar Pradesh had a great contribution in 'Green Revolution' and still provide bulk of rice and wheat in the national food basket. Inclusion of high-yielding varieties of rice and wheat in cultivation practice results in production of bulk crop residues in above mentioned states. The wheat and basmati straw is generally managed by the farmers and utilized as animals feed, whereas paddy straw is mostly burned owing to several reasons. As we know, open field straw burning has harmful environmental effects including air pollution and greenhouse gases emissions besides, huge nutrient loss from soil as well as health deterioration of humans. The nutrient losses from soil and gases released owing to burning of paddy straw are highlighted in various reports by the experts. Moreover, rice straw burning is spreading rapidly at an alarming rate in other paddy growing Indian states, which is a matter of great concern.

Management of paddy straw has remained a big challenge for farmers especially for small and marginal farmers. Factors like short time window between paddy harvesting to wheat sowing, costly machinery, small and marginal farmers, non-availability of labour, high cost in removing residues, etc. forces the farmers to burn paddy straw. Therefore, it is necessary to develop appropriate strategies for *in-situ* crop residue management to achieve 'zero burning'. Though there are number of machines available for crop residue management such as happy seeder, super seeder, mulcher, MB plough, zero till drill, baler (*ex-situ* option), etc., but these technologies are either not available everywhere or are costly to afford by every farmer. However, presently due to lack of economically viable options of paddy straw management, Indian farmers especially from the north-western states viz. Punjab, Haryana and western-Uttar Pradesh become compelled to burn straw in fields itself. So, proper management of crop residues especially paddy straw can improve agriculture waste management and reduce environmental pollution contributed through residue burning. Thus, there is a need for resource conservation, minimized cost production and maximized productivity with technologies that sustain a healthy environment. In this scenario, surface seeding is a novel technique that has potential to improve crop productivity on sustainable basis without causing environmental pollution. Hence, surface seeding-cum-mulching practice of crop residue management has emerged as an economical and viable option in present time. In present arcticle, an attempt has been made to share the experiences of farmers on this emerging technology.

Surface seeding-cum-mulching

- Surface seeding-cum-mulching of wheat (developed

by Punjab Agricultural University, Ludhiana) is a low-cost ecofriendly technique, in which paddy harvesting and wheat sowing gets done simultaneously.

- An attachment fitted with combine harvester uniformly broadcasts wheat seed and basal fertilizer during paddy harvesting followed by manual operation of mulching with the help of cutter-cum-spreader and applying light irrigation.
- In this technique, stubbles are harvested at 3-4 inches above the soil surface.
- The PAU experts have recommended 45 kg wheat seed and 65 kg DAP fertilizer application per acre at the time of sowing.
- Where such option is not available, farmers also broadcast the recommended seed and fertilizer manually in the field after harvesting of paddy with combine followed by cutting of stubbles with cutter-cum-spreader and irrigation.
- The Punjab Agricultural University, Ludhiana scientists have also developed a machine 'Surface Seeder' for direct sowing of wheat. It uniformly distributes wheat seed and fertilizer while simultaneously cut and spread the entire straw harvested with Super SMS loaded combine.
- This technique is very economical in managing paddy straw.
- Compared to existing residue management options, this method has benefits with respect to weed control, soil health as well as crop productivity along with economic benefits as costly machines and high-power tractors are not required in this technique.

Wheat crop sown by surface seeding-cum-mulching technique in farmers field in Tarn Taran district

Benefits of surface seeding

As we know during 2022-23, thousands of farmers of Northern India including Punjab were affected with moderate to heavy lodging of wheat crop on large area due to torrential rain and hailstorms in the month of March. However, the farmers who opted for sowing of wheat by surface seeding method experienced less damage compared to other crop residue management practices and their crop resisted to lodging. As per scientists, this technique provides complete mulching, which keep the soil profile moist and saves the crop from terminal heat stress. Further, surface seeding of wheat develops fibrous root system on the upper layer of the soil. When plant is fully grown, fibrous root emerges from the ground a mat, thus holding the soil surface. These roots play pivotal role in stabilizing the plant to prevent lodging especially during adverse conditions like hailstorm, etc. The PAU scientists have listed several benefits of surface seeding over conventional methods of residue management, some of which are:

- With this technique, straw management and sowing operation of wheat can be completed with a merge cost of ₹650 only compared to ₹2000-2500 per acre for conventional methods.
- There is no need of costly machines and tractors with high 'horse power' for paddy straw management.
- It meets out the concept of *in-situ* crop residue management that ensure healthy and porous soil system.

S. Gurbachan Singh explaining about the root system on wheat plant sown by surface seeding method

[*You can watch this on link https://www.facebook.com/share/v/oyymoDLboFowGYjx/?mibextid=oFDknk]

- As this technique provides complete mulching over the soil surface, crop is saved from terminal heat stress especially during high temperature.
- This technique reduces dependence on costly herbicide inputs as it ensures weed free crop or very less incidence is reported.

Table 1. Comparison of economics of wheat crop sown through conventional farming and surface seeder method*

Operation	Cost of cultivation (₹/acre)	
	Conventional farming	Surface seeding
Field preparation	2500	650
Seed treatment	1650	1850
Fertilizer	2450	2450
Plant protection	2150	1750
Irrigation	350	350
Harvesting operation	2000	2000
Watch & ward	2000	2000
Transport and marketing	1000	1000
Total	14100.00	12050.00

*These are approximate cost and may vary with farmer to farmer based on practice followed or seed or fertilizer application rate

Farmers' experiences

S. Gurbachan Singh
Village – Burj Deva Singh
Land holding – 36 acres
CRM experience – 18 years
Surface seeding: For 5 years

- S. Gurbachan Singh is a known face from district Tarn Taran in the field of Agriculture, whose name was mentioned by Hon'ble Prime Minister of India in *Mann ki Baat* for crop residue management.
- He is adopting surface seeding-cum-mulching technique of wheat for 5 years (https://fb.watch/q0Fgf_NI6r/?mibextid=RtaFA8).
- As per him, more fibrous roots are developed in surface seeded wheat that protects the plants from lodging (https://fb.watch/q0EkpQ96KZ/?mibextid=RtaFA8).
- Wheat sown by limesing surface seeding method was very less affected by the harsh weather conditions last year.
- He said that surface seeding technology keep field weed free and ensure healthy crop stand.
- The crop yield was registered at par with other crop residue management` approaches.
- This innovative approach in paddy straw management and wheat sowing economizes input cost.

As per my experience (S. Gurbachan Singh), in this technique, fertilizer is placed (by broadcasting) at proper distance from seed and that is the reason more fibrous roots are developed to capture the nutrients. Moreover, in surface seeding, seed is placed over the soil surface that's why more fibrous roots are developed on and or near the soil surface, whereas in conventional methods or other crop residue management practices, the seed is placed at 4-6 cm deep in soil so fibrous roots are developed at same depth and supporting roots develop near surface.

Fibrous roots development in wheat plant sown by surface seeding method

Fibrous roots development in wheat plant sown by Happy Seeder method

S. Jaskaran Singh
Village – Burj Deva Singh
Land holding – 35 acres
CRM experience – 18 years
Surface seeding: For 3 years

- S. Jaskaran Singh is also practising surface seeding-cum-mulching in wheat crop from last 3 years.
- He started with 3 acres about three years ago and expanded to 30 acres at present.
- He is very much convinced with the performance of this technology and gets yield up to 22.0 q/acre.
- He observed that this technique provides one quintal higher wheat grain yield per acre and saved irrigation as compared to the conventional sowing methods.
- He explained the benefits like low cost, weed free field and better yields.
- Besides, all paddy straw is managed *in-situ* without any expensive machines.

S. Balraj Singh Kulla
Village – Kulla, Patti
Land holding – 38 acres
CRM experience: 10 years
Surface seeding: For 3 years

- He also shared his experiences on surface seeding stating that by following surface seeding of wheat, it costs hardly ₹600-700 per acre for sowing operation, whereas conventional required ₹2500-3000 per acre for field preparation including straw management to sowing operation.
- This is also cheaper than other crop residue management practices/ machinery such as Happy Seeder, Super Seeder, Mulcher, Incorporation, etc.
- He experienced that surface seeding is not much successful on very heavier soils or soils with low permeability. However, it is highly successful on comparatively lighter soils.
- Water management is an important factor in surface seeding of wheat.
- He gets 22.0 quintal per acre wheat yield through surface seeding-cum-mulching technique of wheat.

The wheat sown by this method take about one more week to mature and straw comparatively remain greener than other practices of wheat sown as soil profile remain moist owing to coverage of soil surface with mulch. This technique also saves at least one irrigation in whole season. Surface seeder plants get more nutrition because of more bunches of roots so plants are more vigorous than other practices.

SUMMARY

Surface seeding is a viable option for *in-situ* management of crop residue. As this technique does not require any costly machines and high-power tractors, it is much economical compared to other residue management approaches. It could be proven as boon to resource poor small and marginal farmers who are otherwise not able to purchase costly machinery to manage crop residues. The adoption of surface seeding practices has the potential to increase the production of wheat and mitigation of heat stress as also registered by the farmers. Efforts are needed to motivate the farmers towards this technology through awareness programmes and demonstrations in farmers' field. As this is a very young technology, it needs further validation in term of seed rate, fertilizer application, type of soil suited for this technique and quantity of irrigation to be applied, etc.

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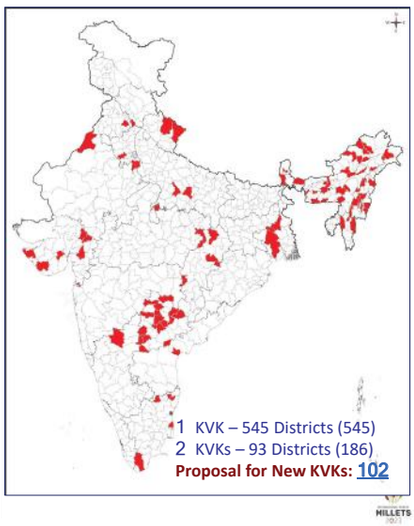
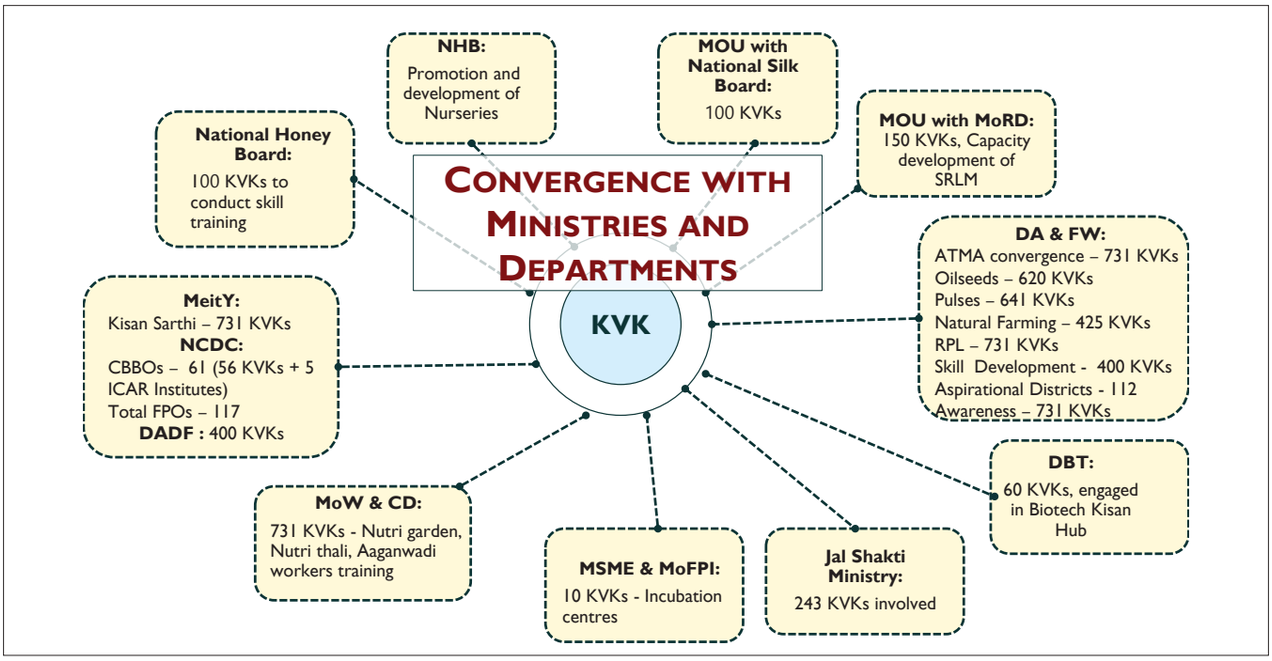
AGRICULTURAL TECHNOLOGY APPLICATION RESEARCH INSTITUTE (ATARI)

11 ATARIs for Effective Monitoring

Zone		State	KVKs
I	ICAR-ATARI-Ludhiana	Punjab, Uttarakhand, Himachal Pradesh, Jammu & Kashmir, Ladakh	72
II	ICAR-ATARI-Jodhpur	Rajasthan, Haryana, Delhi	66
III	ICAR-ATARI-Kanpur	Uttar Pradesh	89
IV	ICAR-ATARI-Patna	Bihar, Jharkhand	68
V	ICAR-ATARI-Kolkata	West Bengal, Odisha, Andaman & Nicobar	59
VI	ICAR-ATARI-Guwahati	Assam, Arunachal Pradesh, Sikkim	47
VII	ICAR-ATARI-Barapani	Tripura, Nagaland, Manipur, Mizoram, Meghalaya	43
VIII	ICAR-ATARI-Pune	Maharashtra, Gujarat, Goa, Daman and Diu, Dadra and Nagar Haveli	82
IX	ICAR-ATARI-Jabalpur	Madhya Pradesh, Chhattisgarh	82
X	ICAR-ATARI-Hyderabad	Andhra Pradesh, Telangana, Tamil Nadu, Puducherry	75
XI	ICAR-ATARI-Bengaluru	Karnataka, Kerala, Lakshadweep	48
		Total	731





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Utilization of crop residue

as an asset *vis-à-vis* crop nutrients and soil health

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Rice-Wheat cropping system is essential for food security of India which faces challenges of post-harvest residue management. Over the years, the paradigm shift has been utilized for in-situ rice residue management with its impact on soil health and sustainability of the production system. Recognizing rice residue as a valuable resource, in-situ practices like surface mulching and incorporation into soil are explored for enhanced productivity and environmental sustainability. Investigating nutrient cycling, microbial dynamics, and physicochemical properties, the delicate balance between productivity and preservation is highlighted. In situ management significantly influences moisture content, bulk density, porosity, aggregate stability, pH, cation exchange capacity, organic carbon, and nutrient content, which are crucial for sustainable agricultural practices. The Government of India through ICAR institutes, SAUs, KVK system introduced crop residue management project to popularize the proficient machines like happy seeder, super seeder, and zero till seed drill for in-situ residue management and conservation tillage for improving soil health 2018 onwards. The outcomes of the project have been very encouraging including enhanced crop yields and cost-effectiveness, reinforcing the importance of in-situ residue management for sustainable agriculture. This exploration aims to inform stakeholders, policymakers, and researchers, fostering a collective effort towards harmonious coexistence between agricultural productivity and soil health in rice cultivation.

Keywords: Burning, Crop nutrients, Crop residue, Mechanization, Soil health

RICE is the predominant crop of India with over 44 million ha area and more than 130 million tonnes annual production. The dwarf varieties of rice are characterized by the accumulation of substantial amounts of biomass, which after harvest as crop residue presents a challenge that extends beyond the fields. The management of rice residue has emerged as a critical facet in the quest for sustainable agriculture, particularly in the context of *in-situ* practices. According to estimates about 300 million tonnes of crop residue is produced annually in rice-wheat cropping system in India.

Rice residue, comprised of straw and remnants left after harvesting, has historically been viewed as a by-product, often disposed of through burning or other conventional methods. The conventional approach, while providing a quick solution for field clearing, has raised environmental concerns, contributing to air pollution, nutrient loss, and alterations in soil parameters. In response to these challenges, the paradigm is shifting towards the *in-situ* management of rice residue as a strategic avenue for promoting both agricultural productivity and environmental sustainability.

In recent years, there has been a growing recognition that rice residue, far from being a waste material, holds untapped potential as a valuable resource for the enhancement of soil health. The shift towards *in situ* management entails practices like surface mulching or incorporating residue into the soil, aiming to maximize the positive impacts on soil structure, nutrient content, and overall sustainability. However, understanding the nuanced effects of these practices on soil health is essential to strike the delicate balance between agricultural productivity and environmental preservation.

Impact of *in situ* rice residue management on soil health

Soil's physical properties

Moisture content: Incorporation of rice residues in soil helps in improving soil moisture content due to

reduced surface runoff and direct evaporation from surface, enhances soil saturated water conductivity and improves water infiltration in the soil profile. The straw coverage on the soil surface can effectively reduce topsoil temperatures affecting the evaporation and thus enhance soil moisture content. The higher moisture availability in soil add to water holding of soil and availability of moisture for better crop productivity.

Bulk density: The bulk density of soil becomes low with enhanced management of rice residues which signifies an improvement in porosity and soil aeration and ultimately in soil structure. The different crops residue and their management have differential effect on soil bulk density across soil profiles and growth periods.

Porosity and aggregate stability: Positive effect of chopped and crushed crop residue incorporation in soil have been reported on soil porosity and aggregate stability. The organic matter addition through crop residues contributes to formation of larger and more stable soil aggregates. It helps in maintaining soil structure and nutrient cycling.

Soil's chemical properties

The *in situ* management of rice residues significantly influences various soil chemical properties, contributing to improved soil health and enhanced crop productivity.

pH and cation exchange capacity (CEC): Crop residues play a crucial role in regulating soil pH, particularly in soils with low buffering capacity. Incubation experiments have demonstrated that the ameliorating effects of crop straw decayed products can lead to a substantial increase in soil pH. However, certain practices, such as straw coverage with no-till and rotary tillage, may result in a reduction in soil pH. Additionally, crop residue management has a pronounced impact on cation exchange capacity (CEC). Accumulation of soil organic matter in crop residues generates more negative charges, leading to increased CEC. Studies have shown that higher crop residue retention levels correspond to significantly higher CEC, emphasizing the importance of residue management in influencing soil chemistry.

Organic carbon and soil nutrient content: Decaying crop residues are integral components of the nutrient cycle, contributing to increased levels of organic carbon, nitrogen, available phosphorus, and potassium in the soil. Organic carbon content, a vital indicator of soil stability, sees a notable rise with crop residue returning, fostering the formation of large aggregates. This process enhances soil properties and stability. Furthermore, the return of crop residues prevents nutrient loss and improves the availability of essential nutrients. Crop residues, comprising approximately 40% organic carbon, become a key factor in regulating soil properties and minimizing organic carbon loss.

Nitrogen: Crop residue returning increases the soil's available nitrogen, crucial for protein, amino acid, and nucleic acid formation. However, the relatively high C/N ratio of crop residues may lead to nitrogen immobilization, necessitating additional nitrogen fertilizer application.

Phosphorus: Long-term crop straw incorporation elevates soil available phosphorus levels, contributing to enhanced phosphorus use efficiency over time.

Potassium: Crop residues facilitate the release of ionic potassium, leading to its accumulation in the soil. Various studies demonstrate an increase in available potassium content with the application of different crop residues, indicating its positive impact on soil fertility.

The incorporation of crop residues has been found to significantly increase organic carbon by 33.3-40.9%, emphasizing its crucial role in recycling soil nutrients and enhancing soil fertility and productivity. The dynamics of organic carbon are pivotal for understanding its profound impacts on soil health and, consequently, on the overall biological health of the soil.

Precisely, careful management and incorporation of rice residues *in situ* enhances the chemical properties and contributes to sustaining soil health and enhancing crop productivity.

Soil's biological properties

Contribution of *in situ* rice residue incorporation adds to soil biological properties and thus vital for sustainability in view of the critical role of soil micro flora and fauna for maintaining the soil biological health. As such the soil biological properties have high degree of sensitivity for changes in soil management as compared to chemical and physical properties.

Macro-fauna and residue incorporation: The most important macro-fauna is earthworms which help in improving the soil health. It has been established that bio-matter alike of crop residue enhances earthworm populations substantially. An addition of 5 tonnes of crop residue in a hectare increases the earthworm population by about 30%. The increase in macro-fauna helps increasing population of friendly insects and predators against insects-pests and weeds. Retention of crop residue along with no tillage build up habitat for soil macro-fauna, including arthropods and rodents. However, not all crop residue yields similar impacts on earthworm's population. The crop residue containing high C:N ratio and polyphenol concentration are less effective in augmenting microbial activity.

Role of soil micro-fauna and microbial communities: Soil micro-fauna, dependent on soil organic carbon for metabolism, are crucial for nutrient cycling and ecosystem sustainability. Changes in soil organic carbon content directly impact microbial populations, compositions, and functions. The addition of crop residues has been observed to rapidly enhance microbial activity, improving the soil's ecological environment. Microbial communities, integral to soil ecosystem processes and biogeochemical cycles, are influenced positively by crop residue returning. The increased organic matter content in the soil provides an optimal environment for the growth and proliferation of microorganisms.

In conclusion, the incorporation of rice residues *in situ* significantly influences soil biological properties, shaping the dynamics of both macro- and micro-fauna, and microbial communities. Understanding these

intricate relationships is essential for implementing agricultural practices that not only enhance crop productivity but also promote the long-term health and sustainability of the soil ecosystem.

Proficient machines for *in situ* management of rice residue

Happy seeder: Happy Seeder has revolutionised farm machinery segment designed for efficient wheat sowing. This innovative machine allows farmers to sow wheat seeds directly into the soil in field vacated after rice harvest. This machine effectively cuts and lifts the previous crop residues and simultaneously allow sowing of seeds, promotes no-till farming practices, conserves soil moisture and improves soil health. This sustainable approach not only enhances wheat cultivation but also addresses environmental concerns by reducing air pollution associated with traditional residue burning. Happy Seeder stands as a promising solution for modern and eco-friendly wheat sowing in agriculture.

Wheat sowing by Happy seeder

Super seeder: Super seeder is an improvement over happy seeder wherein rotavator is added which accomplish all the shallow tilling and all other activities of happy seeder for wheat sowing. This machine also allows farmers to sow wheat seeds directly into the soil effectively cutting and lifting the previous crop residues simultaneously. The Super Seeder, although an improvement over happy seeder but its efficiency and advantages are yet to be established in the field. Farmers are still preferring Happy seeder for its higher yield advantage in wheat.

Wheat sowing by Super seeder

Zero till seed drill: The Zero till seed drill is an innovative agricultural tool that revolutionizes wheat sowing practices. Unlike traditional methods that involve plowing and tilling the soil before seeding, the Zero till seed drill allows farmers to sow wheat directly into untilled soil, minimizing soil disturbance. This conservation tillage approach helps retain soil moisture, prevents erosion, and promotes overall soil health. The machine features precision seed placement, ensuring optimal spacing and depth for uniform crop emergence. The Zero till seed drill is a sustainable solution, saving time and energy while contributing to enhanced wheat yields and environmental conservation.

Wheat sowing by Zero till seed drill

Crop residue management project

The Government has taken proactive measures to combat the detrimental practice of residue burning through the implementation of a centrally sponsored scheme "Promotion of Agricultural Mechanization for *in-situ* Management of Crop Residue", since 2018. The scheme has been collaboratively implemented by DAFW, ICAR, State Agriculture Departments and 60 frontline extension institutions (KVKs) spread in the districts of Punjab, Haryana, Delhi and Uttar Pradesh.

Wheat yield and cost of cultivation

Agricultural machines (Happy seeder, super seeder, and Zero till seed drill) were demonstrated on the farmers' fields. These machines were utilized for sowing of wheat consequently managed rice residue *in situ* and also contributed significantly to increase the crop yields compared to conventional methods of sowing. The use of happy seeder machine yielded the highest grain yield of 51.74 q/ha of wheat in demonstration plots. The grain yield of wheat under super seeder and Zero till seed drill were almost equivalent at 50.91 q/ha and 50.89 q/ha, respectively. While the conventional methods of sowing

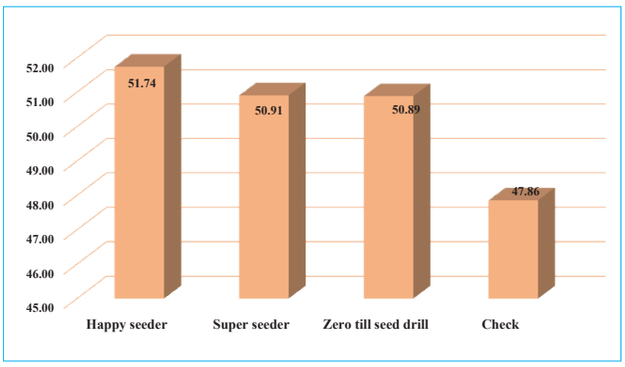

Fig. 1. Effect of different CRM machines on wheat yield (q/ha)

of wheat, due to its limitations, yielded the lowest of 47.86 q/ha, it incurred the maximum cost of cultivation of ₹41787/ha closely by ₹41201/ha by super seeder. Use of happy seeder incurred total cost of ₹35537/ha in wheat cultivation slightly higher than the lowest of ₹34926/ha under Zero till seed drill.

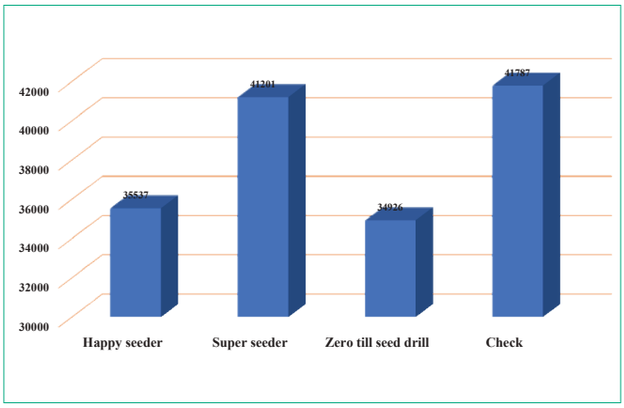

Fig. 2. Cost of cultivation (₹/ha) of wheat under different CRM machines

Monetary advantages

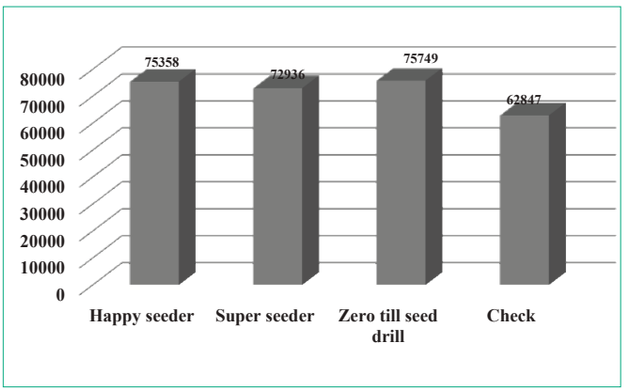

Fig. 3. Net income in wheat under different CRM machines (₹/ha)

The highest monetary advantage and efficiency *i.e.* net income and benefit:cost ratio of ₹75749/ha and 3.39, respectively were recorded with Zero till seed drill followed by the Happy seeder (₹75358/ha and 3.17) and Super seeder (₹72936/ha and 2.99). The conventional method gave significantly lower returns (₹62847/ha and 2.66).

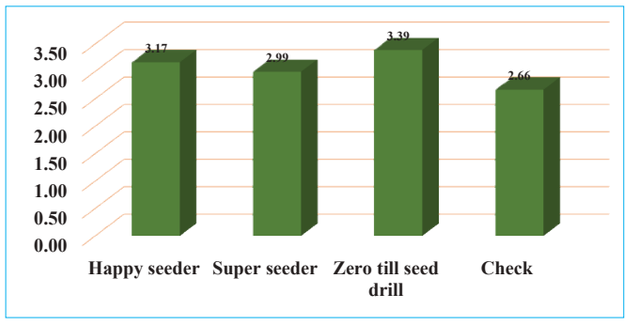

Fig. 4. BC ratio in wheat under different CRM machines

Information, Education and Communication (IEC) for last mile connectivity and awareness

District level frontline extension agencies of Haryana and Delhi organised 1218 campaigns during 2018-2023, at village, block and district level with the participation of 99,735 farmers. Besides, 331 training programmes were also conducted in which 13,746 farmers were trained for residue management practices. Rice growing farmers were given five-day trainings in collaboration with the state department of agriculture. The campaigns also included detailed information about schemes and incentives to farmers on crop residue management machinery and custom hiring centres. In Haryana and Delhi, students of 416 schools and 102 colleges were mobilized through essay competitions, paintings, debates, etc. and about 39,580 students were informed about benefits of *in situ* crop residue management. Total 103 farmers' fairs were organised in Haryana and Delhi with the participation of 65,511 farmers from nearby villages. Live demonstrations of machineries used for crop residue management after harvesting of rice were made in these farmers' fairs.

SUMMARY

Use of *in situ* crop residue management machines could turn 'so called' waste or residue into a much 'productive' asset contributing towards 3.23 kg/day in the productivity and ₹104.3 /day in net return. Beyond the food security and economic indicators, the *in-situ* residue management also contributes towards soil sustainability and is an environment friendly activity. The frontline extension institutes in target states of Punjab, Haryana, Delhi NCR and Uttar Pradesh proactively undertook these machines to farmers' fields for their popularization and infuse 'pull' effect for creating demand of these machineries. The State Governments should incentivised both individuals and community approach for upscaling machineries. The community frontline extension approach with active participation of public leadership, social and civil society organizations, children, students, teachers and spiritual leaders helped in better mobilization of society and all stakeholders responsible for an 'inclusive' ecosystem for the success of any movement of this nature.

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Popularization of mothbean cultivation
in Rajasthan

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India experienced pulses revolution during last 10 years due to the concerted efforts of all stakeholders. One of the innovation in frontline extension approach implemented since 2016-17 was FLDs in clusters in place of individual farmers' field. The CFLDs were initiated under ICAR-DAFW collaborative project implemented by frontline extension institutions at districts. This proved an effective tool in educating farmers about improved cultivars and agro-techniques of pulses. Over a dozen pulse crops are grown in one or the other part of the country. One of the most climate resilient and stress adaptive pulse crops in India is mothbean, of which over 94% is produced in arid region of Rajasthan. The farmers harvest very low productivity of this crop due to traditional practices and use of farm saved seeds of old varieties. The CFLDs on mothbean were implemented in 6 districts of western Rajasthan for popularization of improved technologies amongst farmers. The demonstrations proved the merits of improved package of practices and varieties with 34.7% yield advantage over farmer's practices and farm saved seeds of crop varieties. In monetary terms, ₹27.8 lakh additional income was generated from CFLD farmers' fields. The CFLDs have been unique in attracting the farmers and extension personnel for understanding the improved technologies and future requirement to fine tune or modify the technologies for easy adoptability at farmer's fields. Improvements in this approach with continuous and coordinated efforts shall help in developing and deploying high-yielding and climate resilient varieties as well as practices of moth bean for diversified agri-food systems in the arid regions.

Keywords: Arid, CFLDs, Frontline extension, Income, Mothbean, Pulses, Rajasthan

INDIA is a global leader in production and consumption of pulses. It shares about 25% of the global pulse production and consumes nearly 27% of it. While the grains of pulses are the rich source of plant protein to a large vegetarian masses in the country, the intrinsic capacity of pulses to assimilate atmospheric nitrogen through root-rhizobia symbiosis and its biomass once incorporated in the soil adds to sustainability of pulse based production systems. The pulses, in a given cropping system, economises applied nitrogen requirement to subsequent cereals to the tune of 30-40 kg/ha. In India, more than a dozens of pulses such as chickpea, pigeonpea, mungbean, urdbean, lentil, field pea, french bean, horse gram, moth bean, cowpea, lathyrus, etc. are cultivated in different cropping seasons and situations across the country. Mothbean (*Vigna aconitifolia*) is an important pulse crop of arid region due to its-inherent adaptive attributes to withstand against a diverse array of abiotic and biotic stresses that commonly limit the yield of other pulse crops of the *vigna* species. This crop is predominantly grown in the arid region of Rajasthan. The total acreage under moth bean during 2021-22 was 9.93 lakh ha with total harvest of 3.43 lakh tonnes at 346 kg/ha productivity. Of the total production, 94% is produced in Rajasthan (AGRISTAT, 2021). The acreage, production and productivity of mothbean in India is given in Table 1.

Demand and supply of pulses

The working group of NITI Aayog on Demand and Supply projection for agricultural commodities and inputs estimated a consumption demand of 35.23 million tonnes in 2032-33 (Fig. 1). The deficit in demand and supply are met through imports which is about 14% global trade of pulses. Over the years, this deficit has reduced substantially due to significant increase

Table 1. Area, production and productivity of mothbean in India

State	Area ('000 ha)	% Share of India	Production ('000 tonnes)	% Share of India	Productivity (kg/ha)
Rajasthan	972.99	97.9	324.27	94.48	333
Gujarat	14.79	1.5	7.71	2.24	521
Himachal Pradesh	3.35	0.3	10.11	2.94	3014
Jammu & Kashmir	1.09	0.1	0.78	0.22	718
Chhattisgarh	0.54	0.1	0.17	0.04	315
Haryana	0.32	0.03	0.16	0.04	500
India	993.08	100	343.19	100	346

Source: Ministry of Agriculture & Farmers Welfare, GoI, 2021.

in pulses production since 2013-14 onwards. However, being largely rain dependent crop and grown in stressed conditions, the intermittent productivity shocks are not uncommon causing shortfalls in supply and forces for imports to meet the consumption demands. In order to meet the projected demand of 35.23 million tonnes of pulses by 2032-33, a growth of 2.2% per annum is required in pulses production. As the luxury of area expansion under pulses has almost dried up due to similar incentives, price signals and level of productivity in competing and companion crops, the productivity enhancement is the sole option for enhancing pulses production. This requires a paradigm shift in technology development and deployment besides commercialization along with capacity building of the stakeholders. Exploitation of available yield reserves to realise higher production and genetic enhancement for yield and quality would be a critical factor in raising the productivity. The supply projections of NITI Aayog projected availability of 33.95 million tonnes of pulses in 2032-33 which implies a deficit of about 1.28 million tonnes. Given the present trends of growth in pulses production, this seems to be achievable with utilization and exploration of all opportunities to enhance the pulses production. In the follow up, the innovative cluster approach of demonstration in moth bean was initiated in Rajasthan for achieving higher production of pulses in the state.

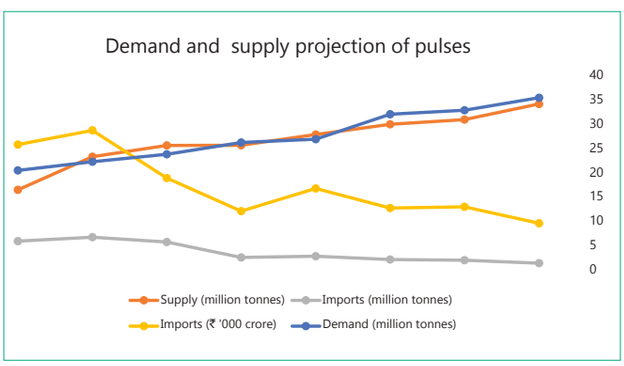

Fig. 1. Demand and supply and imports of pulses during 2015-16 to 2032-33. *Source:* NITI Aayog, 2018

Cluster frontline demonstrations (CFLDs)

A special programme for demonstration of new varieties through Krishi Vigyan Kendra (KVKs) to promote adoption of new varieties of pulses was initiated under National Food Security Mission (NFSM) through a collaborative project of ICAR-DAFW in 2016-17. CFLDs is an innovation over individual and isolated FLDs and technology application research for popularization of the latest notified/released varieties along with full package of practices on a cluster of farmers' fields of a village or more villages. This enables to demonstrate the potentiality of the technologies with scale to participating farmers as well as the farmers of adjacent villages and other agencies. The robustness of precision in outcomes of technology dissemination is enhanced due to economy of scale so is the opportunities for performance analysis and the feedback of practitioners. The frontline extension agencies in Rajasthan under ICAR-ATARI, Jodhpur have been implementing CFLDs on mothbean. During 2022, CFLDs on 340 ha involving 840 farmers were conducted in stressed districts of Bikaner, Barmer, Churu, Jaisalmer, Jodhpur and Nagaur in western Rajasthan. Full packages of practices of mothbean including newly developed varieties, sowing methods, seed treatment, integrated nutrient management (INM), use of micronutrients, bio-fertilizers, integrated pest and diseases management and intercropping, etc. were implemented. The attributes of demonstrated varieties of mothbean are presented in Table 2.

CFLD on Mothbean variety RMO 257 at farmer's field in Nagaur district, Rajasthan

Table 2. Characteristics of HYVs of mothbean under CFLDs in Rajasthan

Variety/Year of release	Developed/ Released by	Avg. yield	Maturity days	Characteristics
RMO-435 (Maru Bahar) 2022	SKRAU, Bikaner	6-6.5 q/ha	65-67 days	• Mutant derived from RMO-40 through 60 Kr gamma radiations. • Suitable for Rajasthan, Gujarat, Maharashtra. • Erect, short duration variety with good fodder value. • High protein (27%) content.
RMO-2251 (Marudhar) 2018	SKRAU, Bikaner	6.0-6.5 q/ha	63-67 days	• Erect with 3 to 5 branches, suitable for mixed cropping, fodder remains green up to maturity. • Good resistance against sucking pest like white fly and jassid. • Escapes terminal drought.
RMO-257 2006	SKRAU, Bikaner	5.0-5.5 q/ha	62-67 days	• Mutant from Jadia moth through 30 Kr + 0.6% EMS for both grain and fodder production (17.4 q/ha). • Flowers in cluster and small petioles and spreading plants. • Moderately tolerant to YMV. • Broad leaves and shallow lobed with 2-3 pod clusters/leaf axil.

Source: https://seednet.gov.in (Accessed on 09.01.2024)

Yield and yield gap

To demonstrate the potential yields of three leading varieties of mothbean viz. RMO-2251, RMO-435 and RMO-257, demonstrations were organised at farmers' fields. Average yield of 551 kg/ha and net return of ₹17516/ha was obtained with improved varieties and packages of practices adopted in CFLDs compared to 414 kg/ha yield and ₹12537/ha net return under farmers' practices. The yield gap between the yields of CFLDs and that of farmers practice was 34.7% (137 kg/ha) (Table 3 and 4).

Table 3. Performance of mothbean varieties during *Kharif* 2022 in Rajasthan (n=794).

Variety	KVKs	Average yield-FP	Average yield-CFLD	Yield gap (%)
RMO-2251	Bikaner-I	2.80	4.40	57.14
	Bikaner- II	4.90	5.71	16.61
	Barmer-I	3.98	5.12	28.64
	Barmer-II	2.60	4.28	64.62
	Churu-I	4.42	5.45	23.30
	Churu-II	4.93	7.20	46.04
	Jaisalmer-I	4.50	7.30	62.22
	Jodhpur-I	4.47	5.92	32.44
	Nagaur-I	4.99	6.25	25.25
	Average	4.18	5.74	39.58
RMO-435	Jaisalmer-II	4.60	5.35	16.30
RMO-257	Jodhpur-II	3.60	4.41	22.50
	Nagaur-II	3.91	4.75	21.48
	Average	3.76	4.58	21.99
Overall average		4.14	5.51	34.71

Table 4. Economics of mothbean CFLDs in Rajasthan in 2022 (n=794).

KVKs	Economics of FP (₹/ha)				Economics of CFLDs (₹/ha)			
	Cost of cultivation	Gross return	Net return	B:C ratio	Cost of cultivation	Gross return	Net return	B:C ratio
Barmer-I	12,850.0	21,890.0	9,040.0	1.70	14,350.0	28,160.0	13,810.0	1.96
Barmer-II	8,500.0	14,300.0	5,800.0	1.68	10,400.0	23,540.0	13,140.0	2.26
Bikaner-I	14,000.0	23,900.0	9,900.0	1.71	14,500.0	29,398.6	14,898.6	2.03
Bikaner-II	17,550.0	37,645.1	20,095.1	2.15	13,900.0	31,426.6	17,526.6	2.26
Churu-I	13,870.0	27,404.0	15,029.0	1.97	17,340.0	39,200.0	18,487.0	2.26
Churu-II	17,000.0	37,090.0	20,090.0	2.18	18,500.0	49,050.0	30,550.0	2.65
Jaisalmer-I	16,600.0	27,300.0	10,700.0	1.64	15,300.0	29,700.0	14,400.0	1.94
Jaisalmer-II	11,270.0	25,300.0	14,030.0	2.24	12,640.0	29,425.0	16,785.0	2.33
Jodhpur-I	14,470.0	24,585.0	10,115.0	1.70	16,185.0	32,560.0	16,375.0	2.01
Jodhpur-II	9,810.0	19,800.0	9,990.0	2.10	10,600.0	24,090.0	13,490.0	2.20
Nagaur-I	22,685.0	27,944.0	5,259.0	1.23	23,725.0	38,756.8	15,031.8	1.63
Nagaur-II	16,300.0	36,701.3	20,401.3	2.25	17,218.6	42,915.3	25,696.6	2.49
Average	14,575.4	26,988.2	12,537.4	1.88	15,388.2	33,185.2	17,515.9	2.17

Intra and Inter variations across district and varieties

Substantial inter- and intra-variety as well as inter- and intra-district variations were observed in the performance of mothbean under farmer practice as well as CFLDs. A much wider intra-variety variation of 12 to 75% in productivity was recorded under farmer practice against the narrow variation of 20 to 32% under CFLDs. The intra-district and intra-variety variations in Barmer, Bikaner and Churu were 20%, 30% and 32% for mothbean variety RMO-2251, respectively. Interestingly, the inter-variety and intra-district variations were also in the same range at 32% for Nagaur, 34% for Jodhpur and 36% for Jaisalmer. This indicated that introduction of HYVs alone cannot help in managing in realizing the potential yields of mothbean in Rajasthan. The management of natural resources and other yield maximizing options shall have to be put in place in the production cycle for realizing the potential harvests from the HYVs. Mothbean variety RMO 2251 proved the best performing which should be promoted by the state department of agriculture. The gap between yields obtained at demonstrations and farmers practices ranged from 16.3 to 64.6%. The narrowest yield gap of 16.3% was recorded under Jaisalmer conditions with 'RMO-435' mothbean and widest gap of 64.6% under Barmer conditions with 'RMO-2251' variety of mothbean (Fig. 2).

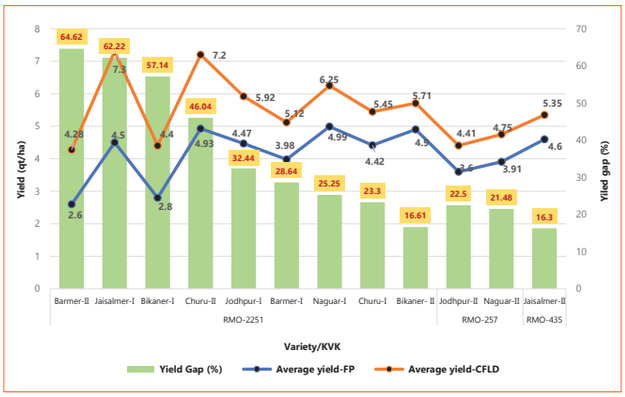

Fig. 2. Yield gap (%) between CFLDs and farmers practice of mothbean in Rajasthan

Income augmentation

Recommended techniques put in practice under CFLDs resulted into higher net return and benefit: cost ratio for mothbean (₹17516/ha and 1:2.17) than farmer practice (₹12537/ha and 1:1.88). On an average, a yield advantage of 137kg/ha was achieved by CFLDs adding to income of the farmers by ₹ 8197/ha. Improved varieties of mothbean under the CFLDs fetched distinct monetary advantage over the farmers' saved seed/ variety. The improved varieties of mothbean proved advantageous in monetary returns by 19.6% with 'RMO-435' at Jaisalmer conditions to 185.8% with mothbean 'RMO-2251' at Nagaur conditions (Fig. 3).

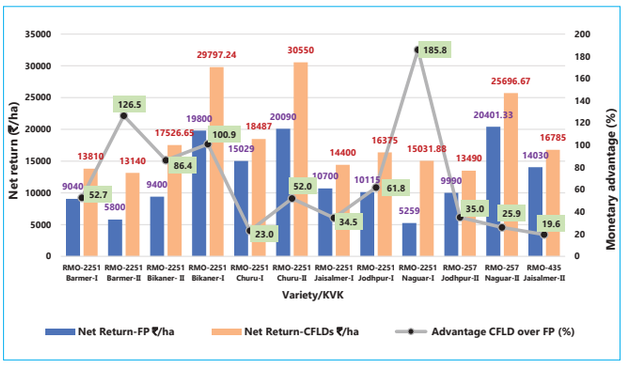

Fig. 3. Monetary advantage of improved varieties of mothbean over farmers saved seed in Rajasthan

Extension activities under CFLDs

The farmers as well as KVKs scientific personnel were broadly capacitated through trainings/workshops and various extension activities viz. organizing field days, field visits by the scientists for crop monitoring and problem solving of farmers, experience sharing etc. In this context, in mothbean CFLDs, a total number of 17 extension activities were conducted with 724 actively involving participants during 2022. Similarly, 330 farmers were trained through 12 mothbean trainings conducted by the KVKs scientists and contributed by forwarding their feedback. CFLDs as an extension approach proved promising for all stakeholders in terms of (i) accessibility, (ii) operability of different interventions and periodic activities/events, and (iii) impacts to farmers of neighbouring villages due to the size of demonstrations and its visibility.

Challenges experienced

- Extreme weather conditions such as abrupt change in minimum and maximum temperatures beyond threshold level of tolerance caused flower abortion, hastened the reproductive period and lowered grain yield.
- The edaphic factors like waterlogging is common feature of monsoon season cropping. Mothbean is sensitive to waterlogging and results in crop failure.
- Lower productivity and low yield potential of mothbean as compared to cereals. Less allocation of resources and sub-optimal nutrition.
- Inadequate availability of seed of improved varieties, vast gap in adoption of agronomic practices and other package of practices.
- Slow growth, long duration, less yields due to poor seed set, and low response to fertilizers. Farmers preferring alternate productive crops resulting into decrease in mothbean area over the years.
- Damage caused by blue bull *(Boselaphus tragocamelus)* and other wild animals.

Future perspectives

- Mothbean is the most suitable and adapted to hot arid and semi-arid agro-climatic conditions, which makes it unique under the climate change and stressed conditions.
- Given its inherent capability of withstanding stresses, mothbean has not been fully exploited for its genetic and genomic resources. Since there are limited number of genetic resources, efforts are

needed for extensive explorations, characterization and evaluation of the collected germplasm. The genetic variability may be employed for higher yield, yield stability, salinity tolerance, multi-disease and pest resistance, higher protein as well as other nutrients.

- Use of advance breeding methods in association with available genetic diversity can help in accelerating domestication in mothbean and expediting its productivity.
- Value-added products and effective marketing strategies can be instrumental in the promotion of mothbean.
- Farmers' participatory varietal development can improve the varietal selection process given that farmers' selection intensity was like that of the breeders.
- Scientific advances coupled with policy signals are required for implementing the innovation and development of high yielding and climate-resilient varieties as well as in mainstreaming of mothbean for diversification of food systems.

SUMMARY

The CFLD approach of frontline extension is an effective tool for increasing the production and productivity of crops as well as motivating the farmers for adoption of improved technologies and package of practices. They have been effective in changing the knowledge, attitude and skills of farmers. Higher yield in demonstration plots over farmers practice created greater awareness and motivation to other farmers to adopt the improved package of practices of mothbean. These demonstrations also built relationship and confidence between farmers and scientists. The beneficiary farmers of CFLDs also play an important role as source of information and quality seeds for farmer-to-farmer dissemination of the high yielding varieties. RMO 2251 mothbean proved the best performing variety which should be promoted through mass extension programme. There is need to augment seed production of farmers preferred varieties at extension farm and farmers' fields in a participatory mode. Efforts may also be augmented for development of high-yielding and climate-resilient varieties of mothbean for diversification of pulses production catering to needs of diversified agri-food systems under diverse agro-climatic conditions.

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Impact Evaluation of KVKs

Third Party Evaluation by NITI Aayog Institute - National Institute of Labour Economics Research and Development (2015 & 2018)

- On an average, each KVK covers 43 villages and 4,300 farmers.
- About 80% of villages covered by KVK are over 10 km away from the KVK.
- Of-campus activities are more than On-campus.
- 96% of farmers' requests were attended by KVKs.
- 42% of technologies adopted resulted in higher productivity.
- Enhanced incomes are spent on better education, health, housing etc.
- On an average, each KVK trained about 100 persons annually on agriprenurship.
- About 25% of the persons trained started self-employment venture.
- KVKs reported an edge over other organization providing technology services.

Third Party Impact Evaluation of KVK Scheme by Indian Society of Agribusiness Professionals (2021)

- Impact of On-farm Trials and Frontline demonstrations is excellent.
- Impact of the IFS models is seen manifolds as compared to other extension activities.
- As per the feedback received from the farmers, demonstration of precision agriculture in farmers' fields should also be taken up in good numbers by KVKs.
- It is required to give demonstrations on improved tools and farm implements including drudgery reduction tools by KVKs.
- KVKs should be promoted and fully equipped for the promotion of entrepreneurs for Agri-clinics and supply systems.

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Agro-based enterprises

A way forward to women empowerment

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Women's contribution to agriculture is significant as they are the major food producers across the world. Though they perform more than 80% of the agricultural activities, their role and contribution in agriculture remain unrecognized and overlooked. Women farmers are identified as an imperative link in the development of agriculture and allied sectors (livestock production, fishing, horticulture, agroforestry, post-harvesting operations, etc.). Women farmers could increase farm yield by 20-30%, which could raise agricultural output in developing countries by 2.5-4%, if they had the same access to productive resources and training as men. Women constitute about 33% of cultivators and about 47% of agricultural labourers (MANAGE 2021). For adding more power to the agriculture sector, recognizing women and strengthening their status from farm to home is the need of the hour. Women empowerment through agro-based enterprise is an emerging solution for establishment of their powerful status and overall development of the society.

Keywords: Agriculture, Agro-based enterprise, Society, Women empowerment

INDIAN rural women are considered as backbone of agriculture and for rural India, agricultural sector is only source of livelihood security and socio-economic upliftment. This sector is the largest contributor to India's GDP, economic development and mainly depend on the women farmer as they play the role of more than 75% of full time labour at the farm according to international humanitarian group OXFAM. The role of Indian women farmer can be elaborated as 85% of their population engaged in agricultural activities, 47% women involved in tree plantation and cotton cultivation, 45% involved in growing oilseeds, 39% in cultivating vegetables and most importantly approximately 60-80% of food produced by them. Indian women play a significant role in agriculture and allied sector since ages which does not need any validation.

Women in agriculture and allied sector

Indian rural women play a significant and crucial role in the agriculture and allied sector. The nature and the extent of work performed by the women farmer vary from region to region. According to Indian Council of Agricultural Research (ICAR 2020), the participation of women is 75% in the production of major crops, 79% in horticulture, 51% in post-harvest work and 95% in animal husbandry and fisheries. Women participation in India gradually increased from 19.67 to 29.56% from 1981-2021 in agriculture and allied sector activities. Because of the migration of male farmers towards cities for alternative source of income generation, the agriculture sector is primarily taken care of by the female counterpart leading to disproportionate concentration of women in agriculture. This phenomenon was termed as 'feminization of agriculture' by Economic Survey, 2017-18. Generally their work can be categorized as labour intensive (paid labour), cultivator and farm manger (supervisor) depending on the socio-economic status of their family. The work performed by them ranges from sowing, transplanting, weeding, irrigation, fertilizer application, nursery management, harvesting, storage, marketing etc. In case of dairy, all the work related to raising of dairy animals eg. feeding, watering, milking, cleaning of animal and sheds, preparation of dung cake, collection of farmyard manure, fodder collection etc. generally performed by them. In case of poultry farming, women participation at household level is central. It is one of the major sources of rural economy. The inestimable role played by women in fisheries is generally underestimated. According to research papers, in the total population of active fishers, 30% are fisherwomen. The contributions of the fisherwomen enter every aspect of pre-and post-harvest handling,

preservation, processing, marketing and provide a vital link between producers and consumers. They are also actively involved in the fish auction, buying fish and later take it to the market for sale.

Role in food and livelihood security

Globally, there is pragmatic evidence that women have a decisive position in ensuring food security, livelihood security and preserving local agro-biodiversity. Rural women are responsible for the integrated management and use of diverse natural resources to meet the daily household needs. UN Secretary-General Ban Ki-moon in his message during celebration of International Day of Rural Women said that 'rural women are farmers and farm workers, horticulturists and market sellers, entrepreneurs and community leaders. Rural women are the backbone of sustainable livelihoods and provide food security for their families and communities.' Livestock is the primary livelihood activity used to meet household food needs as well as supplement farm incomes. Studies have revealed rural women earn extra income from the sale of milk and animals and utilize the money for household works. The rural women rear livestock as an insurance against economic uncertainty. There is practice of rearing small ruminants by rural women and selling them during festive season to earn money. Every woman in the family chooses her goat/ sheep and nurtures them till the market age. Thus woman in rural India not only nurture their family but also provide financial assistance contributing to overall economic development of the country.

Social role

The India rural women are often assigned responsibility to care for family members, stocking supplies and maintaining the household under many unfavourable conditions. Usually it is the women who must stay at home and feed all the family members, the children, old and sick in times of scarcity apart from working in agriculture field and keeping livestock. Women may find themselves burdened with greater responsibilities and work centered on the household. Moreover women involved in marketing suffer the double burden of being women in a traditional and highly prescriptive society and of being engaged in a form of employment.

Women in agribusiness

Agribusiness is the complete value chain in agriculture and allied sector, which involve chain of activities from the raw materials and necessary resources to produce desirable goods and services, distributors and retailers that get products to end consumers. After playing so many roles, the rural women have expanded their wings in agribusiness value chain to improve their livelihood and others by discovering new avenue of income generation. Rural women are involved at all levels of production, pre-harvest, post-harvest processing, packaging, marketing of the agricultural value chain, to increase productivity in agriculture. Globally women are overcoming various challenges to establish profitable agribusiness. However, access to necessary credits, resources, high-value organized markets and incubation to sufficient agribusiness trainings are essential requirements for women entrepreneurs to break through the 'glass ceiling' and expand their agribusinesses to compete on international markets. In order to sensitize women with latest techniques in agricultural sectors and to adopt business of agribased products, trainings are being imparted to women farmers under schemes of Ministry of Agriculture & Farmers Welfare and Ministry of Rural Development.

Challenges of women empowerment

Women working in agriculture and allied sector face many barriers such as lower access to resources, social and labour rights, lower influence and visibility. They hardly enjoy land ownership rights directly in their names. According to agricultural statistics, 73.2% of rural women work in agriculture sector but only 12% of them own agriculture land. This shows the huge disparity in land holding in comparison to their male counterpart. Limited access to arable land further limits livelihood options and worsens monetary pressure on women, especially in women-led households. Women perform multiple task related to unmechanized agriculture which add more burden on them due to lack of equipment and appropriate technology as most of the time they are unaware about the improved technology. Little contribution in decision making process, either inside home or on the field made them unrecognizable. Few women own agricultural productive resources such as land, animals and machinery but their percentage is always less. Due to financial limitations, poor women farmers are unable to purchase innovative, climate resilient technology to improve productivity. Women farmers in agriculture and allied sector often suffer from high illiteracy rate. Women earn fewer wages, especially in joint, informal and private sector. Lack of market intelligence, weak bargaining power with the buyers and inadequate information put women farmers under miserable situation. The gender inequality in rural India further aggravates the pathetic conditions of women. All these issues in the way of women empowerment should be checked step by step with sustainable solution approach.

Empowering the powerhouse (women) of rural India

Empowering rural women with agricultural skills and resources will considerably augment their productivity, while ultimately contributing to economic growth and income generation. Providing rural women with the knowledge to produce better quality crops, with higher yields and judicious use of precious resources will also help them to become more empowered, enabling them to uplift their socio-economic status, community growth and feeding growing population. Capacity building for improving entrepreneurial skills and training on practical use of agricultural technology may

help in improving their self-esteem. Access to academic education, protection against gender discrimination, provision of equal rights in every accessible dimension, raising public awareness regarding their importance in farming, agriculture, food and livelihood security are the some actions that can be taken to empower the women.

Role of agro-based enterprise towards women empowerment

Smt. Pratibha Trivedi is a 46-year-old woman farmer from Village - Saraiya, District - Sitapur, Uttar Pradesh. Today, as an independent farmer, she is able to feed her family with nutritious food and provide employment opportunity for women farmers in her village through small agro-enterprise. She never let her morale down even though she was not physically strong. Post graduate in Hindi and having little knowledge about agricultural sector, with the help of KVK, Sitapur II, she adopted the innovations of agriculture and allied sector on her small land to support her family. Now she has made her identity as a successful woman farmer and entrepreneur.

Prior to this, Mrs. Pratibha Trivedi was a traditional farmer who owned an acre of land, adopting old traditional farming methods and growing local vegetables like beans, pumpkin, tomato, gourd etc. to support her family. Due to less knowledge on new agricultural techniques and practices, her hard work was not yielding enough results. Krishi Vigyan Kendra-II, Sitapur interacted with Smt. Pratibha Trivedi in 2016 and motivated her to take up agriculture as agribusiness work, under which she received training on charcoal briquettes from agricultural waste, vermicompost production, lamps and pots making from cow dung and nutrition garden. After the training, she has started her own business and improved her livelihood and income. She has also received many Awards at District Agriculture Departments, Non-Government Organizations, NRLM, Krishi Vigyan Kendra etc.

Outscaling of success

Her journey has inspired many women wanting to uplift their economic status. The other women of the village were greatly influenced by the work and success of Pratibha Trivedi and expressed their desire to work with her. So she formed a group after talking to all the women who wanted to work together and the group was named as *'Sheetal Mahila Svayam Sahayta Samuh'*. The training of all the women in the group was done by Krishi Vigyan Kendra, Sitapur- II. Now the identity of Smt. Pratibha Trivedi and her group has emerged as an example for the women in entire district. Stalls are put up by their group in the exhibitions, fairs etc. as and when organized in the district. There is a lot of demand for the products made by this group during festive season like lamp made from cow dung during Diwali and also similar products. Also the charcoal briquette made by them is in great demand in the local market.

Vermicompost production

Cow dung lamps

Agro-waste charcoal briquette production

Cow dung pots making

Table 1. Economics of agribusiness adopted by Mrs. Pratibha Devi

Unit	Production (Qt/No.)	Rate (₹)	Gross income (₹)	Expenditure (₹)/kg	Net income (₹)
Vermicompost production	40 qt	700/qt	28000	12000 (@ ₹ 300/kg)	16000
Agro waste charcoal briquette	10 qt	280/Kg	280000	150000 (@ ₹ 15/kg)	130000
Cow dung lamps	7 qt	350/Kg	245000	105000 (@ ₹ 15/kg)	140000
Cow dung pots	1200	25/piece	30000	12000 (@ ₹ 10/pc)	18000
Grow bags 15"×15" (Pack of 10)	300 (Packet)	950/pack	285000	150000 (@ ₹ 500/pack)	135000
Total			**860000**		**4,39,000**
B:C Ratio	**1.977**				

SUMMARY

Earlier the women farmers were treated as 'helping hands' of the families for their contribution in agricultural activities. It is established fact that rural women plays vibrant role in Indian agriculture and economy but the irony with women farmer is, that the role played by them is always undervalued and the tag of 'helping hand' has not changed yet. The performance of women farmers is always appreciable and they can succeed in many avenues but they face lot of challenges like limited access to inputs (land, seed, fertilizers etc.), critical services (capacity building) and organized markets to prove their existence as compared to male counterparts. So there is an urgent need of strengthening and empowering the Indian rural women for holistic development of society and our country.

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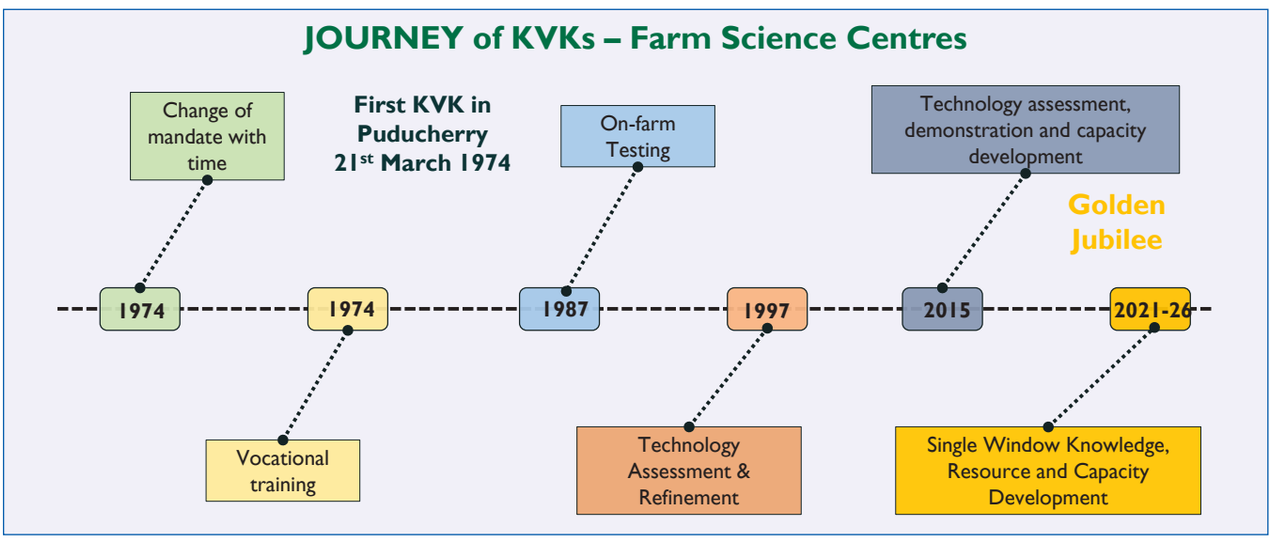

Indian Farming 74 (03): 30-31; March 2024

Fish farming

An ocean of opportunity for enhanced income and livelihood

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Fish farming plays a vital role in improving the socio-economic conditions and livelihood of rural communities. Many studies have shown that pond fish farming is more profitable enterprise than rice cultivation, promoting many poor farmers in rural areas to switch to fish farming with the benefit cost ratio ranging from 1.7 to 1.9. Furthermore, the increasing human population has created a lot of pressure on diminishing agricultural land for food production. Fish farming can be considered as an alternative source of livelihood generation and may act as bridge for achieving one of the goals of SDGs (sustainable development goals) i.e. zero hunger. The blue revolution has significant role in post independence increased production of fish which is considered as a cheap source of protein and contains essential amino acids and fatty acids. The Krishi Vigyan Kendras have emerged as connecting link between the poor farmers and new technology which led to the enhanced production of fish besides livelihood generation.

Keywords: Benefit cost ratio, Blue revolution, Fish farming, Livelihood

FISH farming is considered as one of the oldest occupation and fastest way to enhance poor farmer's income as well as livelihood. It also plays a significant role in improving socio-economic status of the rural community. Fish farming is not only helpful in providing food security but also ensures-nutritional security as an outstanding source of animal protein rich in essential amino acids and fatty acids, weaving the pathway towards achieving the goal of zero hunger (one of the goal of SDGs of UN). After China, India has privilege of being known as second largest fish and aquaculture producing nation. The bloom of fisheries is because of blue revolution which has led paradigm shift in the production of fish from 0.75 MMT in 1950-51 to 13.76 MMT in 2018-19 with annual growth rate of 6.8% (NABARD 2020). This trend has shown immense potential of fisheries sector in doubling the farmer's income. The fish production has two dimensional significance i.e. employment generation and export potential. India's contribution in global fish production is 7.73% and 4% in global export. Fish and fish products in India has share of 7.28% in agricultural GVA and 1.28% in national GVA (APEDA 2020). This sector has role of providing livelihood to approximately 16 million people in fish production and 32 million in value chain of fish farming (National Fisheries Policy 2020). Though India is blessed with long coastal line and inland water bodies, fish farming being supported by many government policies, acceptance of Indian fish and fish products in international market, higher growth rates in aquaculture, are some of the hurdles existing which should be rule out to nurture fish farming and dependent farmers. Major constraints in fish farming are use of traditional methods for fish culture and harvesting, poor access to quality feed and seed, poor processing facility, seasonality in the occupation, poor access to credits, lack of knowledge among farmers about government policies and subsidies, inadequate and poor infrastructure, lack of diversity in culture of fish species, lower productivity due to incidence

Fisherman with the produce

Mr Dinesh with his fish pond

of diseases etc. Considering these issues, here comes the multidimensional role of KVKs in nurturing of aquaculture and development of aquapreneurs. From creating awareness and promotion of fish farming among poor farmers, KVK has vital role in introduction and popularization of new and improved technologies of fish farming.

Role of fish farming in livelihood security

Sri Dinesh Jaiswal, S/o Sri Chotaka, a young farmer belonging to small farmer category was unemployed and habitant of Village – Itwa, District – Chitrakoot (Uttar Pradesh). He was performing crop farming only on a small piece of land. Mr Dinesh searched job and consulted everywhere for employment. Lastly, he decided to do fish farming along with crops. He has 2 ha land in a joint family. Mr. Dinesh consulted KVK Chitrakoot and visited demonstration unit at center. He showed his interest in fish farming. KVK, Chitrakoot trained him in composite fish farming techniques and about pre-and post-stocking management with package of practices. He excavated pond of 2500 Sqm and started fish cultivation with appropriate size of IMC fingerling. After few months, Dinesh stocked 3000 Pungas fish seed in his pond with IMC during 2021-22. Feeding and water quality management was managed efficiently in consultation with KVK Subject matter specialists.

Output

Mr. Dinesh adopted complete package of practices, stocked 5 g size fingerling of Catla, Rohu, Nain and *Pungasius* @ 10000 per ha. The feeding was done by floating fish feed and water quality management by application of lime and disinfectants with the consultation of KVK scientists time-to-time. He stocked IMC during October 2021 and *Pungasius* stocking was done during March 2022. Manuring and fertilization was done properly. He harvested fish during November 2022 and obtained yield up to 118.4 q/ha with B: C ratio of 1.40

Upscaling of the technology

Fishery is a supplementary occupation in the district even after availability of large number of small and medium water bodies. This business is limited to some families belonging to Kewat, Raikwar, Nishad community. Now due to innovations, improved technology and production, youth of other communities is coming forward and adopting fish farming in a scientific way. Nearly 1200 ponds are available in the district and about 977 are engaged under fish farming. After successful fish farming venture of Mr. Dinesh, 15-20 farmers adopted fish farming with *pungasius* variety. The training and demonstration given by KVK, Chitrakoot, motivated many farmers to adopt fish farming for ensuring livelihood and nutritional security. Mr. Dinesh Jaiswal is an example for others who are seeking employment. This new farming has helped him to get extra income and employment opportunity. He is very happy to share his success among others and popularizing this system to others in the district as well as state.

Economic performance of fish production

Performance indicators

Pond	Farmers Pond
Date of stocking	01-04-2022
Area (ha)	0.25
Density	1.6
Initial wt. (g)	5
Final wt. (g)	640
Specific growth rate	1.989

Per Unit Economic performance

Pond	Farmers Pond
Yield (Kg/unit area)	3200
Feed consumed (Kg)	3800
Expenditure (₹)	260000
Gross return (₹)	364000
B:C ratio	1.4
FCR	1.19
Cost/kg (₹)	81.25

Economic performance/ha

Study pond	Farmers Pond
Date of harvesting	30-11-2022
Yield/ha (₹)	11840
Expenditure/ha (₹)	1040000
Gross return/ha (₹)	1456000
Net return (₹/ha)	416000

SUMMARY

Fish farming is a profitable enterprise and can be a viable option for marginal and small farmer to improve their socio-economic status. Furthermore, it could contribute to current issues of food and nutritional security at the household, community and national levels. Fish farming is predominantly appropriate for those farmers who face severe trouble with salinity in their soil, as traditional crops struggle to grow well in saline conditions. Therefore, the fresh water as well as marine fish farming can be treated as alternative source of traditional agriculture and may be integrated with it e.g. fish farming in crop field to enhance the productivity and income.

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Lemon grass cultivation for

enhancing farmer's income

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The rising human health consciousness has led to the use of side effect free natural product based molecule such as Lemon grass. The multiple uses of this aromatic plant such as pharmaceutical, perfumery, soap industry etc. has increased its demand in domestic as well international market, which has also paved the pathway of enhanced income and livelihood generation among Indian farmers. Moreover, cultivation of Lemon grass played an important role in livelihood security of tribal women. Cultivation of aromatic plants needs less input as compared to paddy cultivation as they can be grown with rain water and farmyard manure. For Indian farmer, Lemon grass cultivation is like gold earned from barren land and it also made many farm women socially empowered. KVK-Amroha has played an important role in enhancing production of Lemon grass and increased adoption rate of its farming by technology dissemination using high-yielding variety Krishna among Lemon grass cultivators.

Keywords: Aromatic plant, High yielding variety, Lemon grass, Livelihood generation

WITH the limited land holding and resources, the Indian farmers always try their best to increase the productivity of crops and livestock. The fact, however is, mono-cropping or raising single livestock species cannot help them to combat the present problems of lesser income in agriculture. They need to integrate the agriculture with livestock or diversify the agriculture production. Diversification of cereal crop production into aromatic crop like Lemon grass (*Cymbopogon citratus*) can be lucrative avenue to enhance farmer's income in the agricultural sector. Owing to the rising demand and limited production, Lemon grass has become a highly sought-after product in the national as well as international market. This versatile crop provides numerous health benefits, making it both expensive and popular among consumers. The high demand of this crop is due to multiple use and value addition. It can be sold as it is or may be dried and mixed with tea leaves to earn extra money. The oil extracted from Lemon grass also has huge demand for soap making, perfume industry to ayurvedic medicines, in the market. Many farmers including women farmers from Indian states like Jharkhand, Odisha, Bihar, Panjab, Haryana, Uttar Pradesh, Madhya Pradesh etc. are actively involved in Lemon grass farming for their livelihood security. In order to offer sustainable livelihoods to the rural women, an innovative initiative under National Rural Livelihoods Mission (DAY-NRLM), has been taken up in the form of Lemon grass farming. There are cases like as in Odisha wherein to promote livelihood security, the vulnerable tribal group women are encouraged for Lemon Grass farming. Right from lemon grass cultivation and oil extraction, bottling and packaging of lemon grass oil, is done by the tribal women who make up 80% of the workforce and play a critical role in planting, harvesting, and processing, thus empowering the tribal women. A large number of women living in rural areas of Jharkhand are also transforming their lives and setting an example of livelihood entrepreneurship at the local level by cultivating the Lemon grass. The success stories of these rural women farmers become an inspiration and are so impressive that Hon'ble Prime Minister Shri Narendra Modi, highly praised their efforts in his monthly radio programme *Mann Ki Baat*.

Lemon grass: Brief description

This versatile grass belongs to family Poaceae and genus *Cymbopogon* consisting of approximately 140 species covering wide area of Asia, America and Africa continents. Some species of this aromatic plant are also found in Australia and Europe. The members of this genus also called aromatic grasses due to production

of volatile oils. Lemon grass is monocotyledon and grows up to height of 6 feet in clusters. It has a lengthy inflorescence which ranges from 30-60 cm. This aromatic grass has specific floral arrangement hence derived the name '*Cymbopogon*'.

Lemon grass cultivation: Low cost, high profit

The cultivation of lemon grass is proving to be beneficial for the farmers who are making profit of up to one lakh per year in one acre, compared to meagre one-time initial investment of ₹20,000. One of the important economic traits of Lemon grass is that once it is planted, the crop can be easily harvested for about five years. Its multi-cutting does not involve any cost except for additional irrigation. The composted cow dung is used as fertilizer and applied five times to the field. While applying manure, care should be taken that manure should be applied only near the roots of the plant. While preparing the field, 2 to 3 tonnes/ha of cow dung and additionally 1.5 tonnes/ha should be applied on each cutting. The field should be well ploughed and after ploughing cow dung should be spread well in the leveled field. While sowing in the field, 5 to 8 cm deep hoeing should be done with a small spade and transplanting should be done at the ridges. While transplanting, the distance between plant-to-plant and row-to-row of 7 to 30 or 7 to 45 cm should be kept. Regular watering is essential for optimal growth, approximately at 15 days interval. Water should not stagnate near the plant. This practice ensures a high yield. The production potential of Lemon grass ranges from 40 to 50 quintals per acre. Its market price ranges from ₹3-4/kg. Lemon grass husks can be harvested four to five times in a year. The price of lemon grass oil ranges from ₹1500-2000 per litre.

Lemon grass: A boon for farmers (benefits)

- Diversification of existing agriculture with Lemon grass cultivation requires only a little irrigation. Also it can grow easily with minimum input and care. With scant irrigation facilities, farmers can even harvest Lemon grass four-five times a year and earn up to ₹50,000 per acre per annum. The earnings from the conventional paddy or wheat crops is ₹10,000-15,000 per acre per annum which justify profitability of Lemon grass cultivation.
- The rising health consciousness among the urban people has led to a booming alternative market of natural herbs based products, as majority of consumers seek health in natural products. Natural products are known for their health and medicinal properties with little or no side effects. The Lemon grass having a wide array of bioactive compound and broad spectrum of secondary metabolites with health restorative capacity leading to high market demand and its cultivation at large scale. The use of lemon grass in Ayurveda is still relevant today due to its therapeutic value.
- Lemon grass contains 1-2% of essential oil on a dry weight basis. Lemon grass oil is also known as citronella oil. Essential oils extracted from the Lemon grass are used in manufacturing of perfumes, soaps, cosmetics and detergent, fetching lucrative market price, making lemon grass cultivation more profitable.
- Lemon grass cultivation provides livelihood security to farmers as well as rural women. Lemon grass farmers can also set up their own FPO (Farmer Producer Organization) and Lemon grass oil extraction plant with the help of district administration.
- Lemon grass is also climate resilient plant as it requires little water, can grow on stony land, and helps in both soil and water conservation. It also improves soil health as it can be cultivated by applying farmyard manure.
- Lemon grass has capacity to convert large barren land into fertile land.

Role of Lemon grass cultivation in income generation and livelihood security

Because of multiple benefits and popularity of Lemon grass cultivation, KVK-Amroha attempted replacing farmer's practice with improved veriety of lemon grass for enhanced income. Mrs. Hitesh, a farm woman of village Chakchhavi, district Amroha, was given demonstrations of high-yielding variety of Lemon grass 'Krishna'. She was regularly imparted knowledge regarding improved cultivation of Lemon grass starting from land preparation to harvesting. KVK, Amroha also encouraged her for soil testing and on the basis of results, she was advised for balanced dose of vermicompost with high yielding variety 'Krishna Lemon grass', which was sown in 2021 as per scientist's recommendation in external input regime covering nine hectares. The performance of traditional and high yielding lemon grass variety for oil production is given below in Table 1.

Table 1. Performance of high yielding variety of Lemon grass 'Krishna'

Particular	Traditional method	Scientific method (using improved variety)
1st Cutting quantity	12 litre	20 litre
5th Cutting quantity	60-70 litre	100-105 litre
Annual income (₹)	90,000-1,05,000	1,00,000-1,60,000
Increment		40%

Outscaling of Success

Considering the success achieved by Mrs. Hitesh, the cultivation of Lemon grass was spread across other nearby villages. Currently, 19 villages have adopted cultivation in 175 hectares of land and 300 farmer's field planted with scientific method using high yielding variety of Lemon grass 'Krishna'. The outcome of this technology dissemination motivated the farming communities to replace their traditional cultivation method with scientific method and high-yielding variety.

Sowing of Lemon grass

Standing crop of Lemon grass

Processing of Lemon grass

Lemon grass oil

Lemon grass tea

Mrs. Hitesh has become one of the progressive and learned farm women for others with regards to popularization of Krishna Lemon grass. This technology helped her for livelihood, empowerment, and made her enthusiastic for Lemon grass oil production. Now she became face of change and role model for many women farmer in her district after becoming a part of KVK, Amroha despite her own development. Mrs. Hitesh is very happy with her improved production and set forth example for other farmers and farm women of the district.

Table 2. Economics of Lemon grass cultivation

Year	Productivity (q/ha)	Production of oil (L/ha)	Cost of cultivation (q/ha)	Gross income (₹/ha)	Net income (₹)	B:C Ratio
Ist	60.5	120.00	75500.00	174000.00	98500.00	2.30
IInd	75.0	125.00	63500.00	187500.00	124000.00	2.95
IIIrd	86.50	129.50	65500.00	194250.00	128750.00	3.06
VIth	85.00	128.00	63500.00	192750.00	129250.00	3.04
Total	307.00	502.50	268000.00	748500.00	48050000	2.79

SUMMARY

Enhancing or doubling the Indian farmer's income is always a major concern. Many government policies and scientific interventions are used to uplift the socioe-conomic status of marginal and small farmers. Diversification of cereal crops into aromatic crops like Lemon grass can be helpful for employment and livelihood generation as Lemon grass cultivation is low cost and high profit avenue due to its high demand in the market. With minimum input and care, this crop can be cultivated on wide range of soils. It is also helpful in control of soil erosion during rainy season because of its soil binding properties, thus maintaining the soil health. Furthermore cultivation of this crop with improved variety and package of practices can fetch more prices. Poor tribal communities can be benefitted by growing this aromatic plant as a source of income throughout the year. In this regard, KVK, Amroha has played its role in technology dissemination for improved cultivation of Lemon grass and made many farmers including woman empowered.

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Round the year fodder production model

for small and marginal farmers of Bihar

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Bihar relies heavily on agriculture as its primary source of wealth, playing a crucial role in the overall development of the state's economy. The state government has given utmost priority to the advancement of agriculture. However, the insufficiency of fodder and feed resources in the state has been acknowledged and articulated on numerous occasions. A shortage of feed and fodder stands as a significant obstacle to sustainable livestock development in the state, directly impacting the income and livelihoods of numerous resource-poor livestock keepers. Various constraints, such as the scarcity of feed, fodder, and concentrates, hinder the potential of livestock, leading to substantial losses in terms of production and depletion of livestock resources. In view of this, KVK Banka has promoted village based round the year fodder production model by integrating various approaches to overcome the shortage of fodder and ensuring a consistent supply of green fodder throughout the year for livestock keepers. It has been observed that integrating more green fodder into animal diets has the potential to lower milk production costs. Also, many farmers start relying on common property resources to fulfil their animals' fodder needs after intervention by the KVK.

Keywords: Bihar, Green fodder, KVK, Livestock

BIHAR is basically an agricultural state and nearly three-fourth population depends on agriculture, livestock and allied sectors for livelihood. Livestock is a key source of supplementary income and livelihood especially for small land holdings and landless rural poor households. In 2013, about 93% of milk producers were marginal and small, possessing less than 2 hectares (ha) of land, and together contributed about 90% of total milk production in the state.

About 80% of the total milk produced in Bihar comes from landless poor agricultural labourers and small and marginal farmers (ILRI 2014).The state currently represents the eight largest dairy market in India and produced 11,502 thousand tonnes of milk production during 2020-21 (AHS, GoI). If we see the impressive growth of dairy sector alone, the productivity of milk in Bihar was 0.7 MT per lactating animal comparatively low as compared to other states like Punjab, Gujarat, Uttar Pradesh and Madhya Pradesh productivities, where it is 2.4 MT, 1.1 MT, 1.0 MT, and 0.8 MT per lactating animal, respectively. This lower productivity of milk is attributed to many factors and to a large extent on the availability of feed and fodder to the dairy animals. The availability of concentrate and fodder are directly linked with agricultural crop production system of a particular area in the state. Availability of crop residues is further declining due to adoption of high-yielding dwarf varieties / hybrids and field wastage due to extensive use of grain picker / mechanical harvester in cereal crops. The main reason for green fodder deficit is the low green fodder yield and lesser allocation of lands for cultivation of fodder and pastures.

Importance of green fodder in village-based production system

Traditionally, green fodder is natural feed stuff and it serves as a cost-effective nutrient source for majority of the dairy animals contributing to their overall health and enhancing breeding efficiency. It is highly nutritious, palatable, rich in minerals, vitamins and an economic source of macro-and micro-nutrients. The primary sources of animal feed in the village area of Bihar consist of rice straw, wheat straw, and certain pulse residues without much provision of green fodder. Recent studies conducted in the Indo-Gangetic Plain of the state have

brought attention to the challenge of inadequate fodder and the low nutritive value of available feed resources. This issue becomes more pronounced in the eastern parts of the region, where agricultural resources, especially arable land and water, are increasingly scarce. The scarcity of fodder has a widespread impact on farmers, but it is especially severe for those who are landless or have access to only small plots of land. Similarly, the availability of green fodder round the year especially during summer months for sustained and economical milk production in these areas is of utmost importance. The dairy farmers have been looking forward to improved technology for continuous flow of green fodder throughout out the year. In general, the dairy farmers are suggested to harness the below mentioned fodder cycle (Table 1) for round the year fodder production at their farms. However, in absence of fodder land, they can use the innovative approaches mentioned below as per the feasibility of land and resources.

Innovative approaches for round the year fodder production model

Horti-pastoral system

Table 1. Schedule for round the year green fodder availability

Crop	Area (ha)	Sowing time	Fodder availability	Production (q)
Maize/ Multicut Sorghum + Cowpea/ Guar/Ricebean	0.50	February–March	April-July	500
Multicut sorghum/ Napier grass/ paragrass + Cowpea/ Guar/Ricebean	0.50	June-July	August-November	500
Barseem + *Oat (Multicut)*	0.50	October-November	December-April	600
Maize + Cowpea/ Guar/Ricebean	0.25	March-April	May-June	150
Maize + Cowpea/ Guar/Ricebean	0.25	May-June	July-August	150
Multicut sorghum + Cowpea/Guar/ Ricebean	0.50	June-July	August-November	600
Barseem + *Oat (Multicut)*	0.50	October-November	December-April	600
Napier grass + Cowpea/Barseem (Rabi)	1.00	March-April	Round the year	2000

Horti-pastoral system involves growing of fruit trees and grasses in combination. Fruits tress usually takes about 4-5 years to develop maximum canopy and hence allow cultivation of fodder intercrops in the initial years. Fruit trees form the 1st tier whereas grasses are grown as ground crop. Perennial forage grasses and legumes like *Stylosanthes hamata, Styloasanthes scabra, Cenchrus ciliaris, C. setigerus*, etc and annual fodder crops like copwpea, horsegram, sorghum, oat etc. are ideal crops for horti-pastoral system in semi-arid areas. Natural grasslands are main source of fodder to about 500 million animals in India mainly because the area under fodder production is low (4.4% of total cultivated area). Krishi Vigyan Kendra Banka have grown oat in *rabi* and ricebean, sorghum in *kharif* season in 5 mango orchards of average 2-2.5 acre in Amarpur block of Banka district in 2016. Presently, in Banka district, approx. 31 orchards were used for cultivating green fodder. During the intervention, it was observed that leguminous green fodder like rice bean require less water for growing and act as mulch and green fodder. After 2nd cutting when leave for fruiting, its seed fall down and regenerate in orchard after October. Due to rice bean crop, sunlight does not directly heat the soil of orchard, thereby preventing loss of moisture. Rice bean is a leguminous crop which fixes the nitrogen and improves the fertility of soil.

Intercropping with traditional crop

In rainfed situation, where limited area has facility of irrigation, intercropping of short duration forages in long duration food crops such as potato, which are widely spaced and offer good scope for accommodating legume and cereal forages in inert-row space in additive series was promoted by the KVK. As a result, in potato field about 40% area (av. 17424 sqft/acre) is vacant which was now used for fodder production by farmers. Intercropping of oat with potato is now a common practice in Banka district. In this, there are two types of cultivation practices followed which includes earthing up before and earthing up afterwards. In before earthing up cultivation, oat were sown with potato and cultivated in 30-40 days before earthing up of potato. In after earthing up cultivation, oat was sown after earthing up of potato and harvesting after 45 days. Production was higher in after earthing up cultivation (36.42 q/acre) practice than before earthing up cultivation (25.09 q/acre) practice. Some other examples include grain sorghum where intercropping of cowpea is done. In grain pigeon pea, intercropping of forage sorghum, maize, bajra and

Table 2. Green fodder production (q)/acre mango orchard

Year	Free space (Sq.ft)	Oat	Rice bean	Sorghum	Sorghum + Rice bean
1st	43,387	196.7	123.8	241.85	322.58
2nd	43,117	195.4	122.9	240.34	320.58
3rd	42,723	193.6	121.8	238.15	317.65
4th	42,391	192.2	120.9	236.30	315.18
5th	41,320	187.3	117.8	230.32	307.21
Av.	42,588	193	121	237	317

Sorghum in mango orchard

Oat in mango orchard

Rice bean and sorghum

Mixed grass in mango orchard

cow pea is done. The forages are harvested 50 days after sowing thereby allowing pigeon pea to grow free of competition and produce grain on residual soil moisture. Alternatively, the productivity of these soils could be raised through intercropping of short duration forages in long duration rainy season food crops such as sorghum and pigeon pea, which are widely spaced and offer good scope for accommodating legume forages in inter-row space in additive series. This work has started from farmer of Dhoraiya block of Banka district in 0.5 acre potato field and extended to more than 50 acre potato field of Banka district.

Intercropping of oat green fodder with potato

Use of waste land / bund of ponds for perennial forage production

The intervention taken up by the KVK banka involving one acre pond having a perimeter of 1163 ft. Plantation of Hybrid Napier of av. 233 slip/acre pond at distance of 5 ft were done which resulted in av. yield of 102 q/year and when intercropped with rice bean, yield increased to 139 q/year. Water canal in villages, water channel cum drainage system, irrigation channel and waste land around dairy farm were promoted to be used for fodder production by the farmers. In last five years, fish production have been fast growing in Banka district by more than 200 new fish ponds constructed with the help of fishery department and also farmers self-investment. Around 23 ponds were integrated with dairy farming with cultivation of green fodder at bund of ponds.

Use of top part of harvesting maize crop

It is observed that, among the maize growing countries, India ranks 4th in area and 7th in production, representing around 4% of the world maize area and 2% of total production. During 2018-19 in India, the maize area has reached to 9.2 million ha (DACNET 2020). The average productivity of maize was 3032kg/ha


Hybrid Napier on bund of pond


Water channel cum drainage Guinea grass (*Megathyrsus maximus*)

Around dairy farm (Hybrid Napier)

Irrigation channel Paragrass (*Brachiaria mutica*)

and annual production (grain yield) was 28.72 million tonnes (Agriculture Statistics at a glance 2018). As per the intervention of the KVK, farmers were apprised to use top part of maize as green fodder for their livestock. For this, they are advised to harvest the top part of green maize straw, 15-20 days before harvesting of grains. Dairy farmers were also suggested to preserve this fodder by making silage for scarcity period. The green fodder yield was 34.59 q/ha from maize grain producing crop.

Relay cropping of green fodder oat and berseem with paddy

Traditionally mono-cropped in rainy season as the

Table 3. Comparison of production and cost of production

Crop	Production (q/ha)		% increase	Cost (₹/kg fodder)		First cutting after harvesting (days)		% decrease
	Ploughing	Relay cropping		Ploughing	Relay cropping	Ploughing	Relay cropping	Ploughing
Oat	395	573	45.06	0.80	0.48	56	35	37
Berseem	315	412	30.79	1.56	0.91	56	35	(21 days)

residual moisture is low to support winter season crops in sequential system. Failure of *rabi* fodder was due to late sowing and late harvesting of paddy. In *rabi* season, low irrigation facility was another cause of not sowing of green fodder. Oat/ Berseem seed was broadcasted 5-6 days before harvesting of paddy in the field having moisture. It saved irrigation, ploughing cost and green fodder was ready for harvesting 21 days before than sowing of green fodder after ploughing. Production improved by 45.06 and 30.79% respectively in oat and berseem. More than 15-acre green fodder in *rabi* season were grown through relay cropping in Banka district of Bihar.

Decrease wastage by planned sowing

In most of the area of Bihar, it was observed that the average time taken to complete harvesting of green fodder from field was 15-20 days. Therefore, the first day harvest of the immature fodder and last day harvest over mature fodder resulted in less nutritions fodder. So, sowing of fodder at interval of 5 days and area decided according to animal rearing which fullfill the fodder requirement for only 5 days. So, sowing of green fodder in six groups resulted in 2nd group in mature stage after harvesting of first group and first group fodder again ready for harvesting after harvesting of last group. So planned grazing land were developed under front line demonstration programme at five goat farms in Banka district. It helps in natural grazing, saving of labour for harvesting of green fodder and movement of goat. It enables land use for dual purpose.

Use of non-conventional feed resources

In the state districts, there is scarcity of green grasses

Frontline demonstration of planned grazing land at farmer's field

in March-June. However, palas (*Butea monosperma*) has new green leaves during this time. Hilly area of Katoria, Chanan, Belhar, Fullidumar and some part of Banka block of Banka district have forest of Palas *(Butea monosperma)*. So, use of palas leave as green fodder may combat the deficit of green fodder during scarcity period. The feeding trial on palas leaf as green fodder was also performed under on farm trial (OFT) by the KVK Banka and it was found that palas leaf was palatable upto 200 g/day and increased in weight gain by 630-640 g and average daily gain increased by 8.5-10 g/day. Farmers also successfully made silage by mixing with 50% sorghum.

Low-cost hydroponic green fodder production

Hydroponics is the scientific way of growing plants/ crops in water without any soil, but generally in controlled conditions/ environment. Fodders including maize, barley, wheat, oats, rye, alfalfa and triticale can be produced by hydroponics. Others, including cowpea, horse gram, sun hemp, ragi, bajra, foxtail millet and Jowar have also been grown successfully by the use of hydroponics. Production of hydroponic fodder under low-cost management can be an alternative to traditional fodder production. Feeding of hydroponically grown maize and wheat fodder can improve productive and reproductive efficiency of lactating cows with better economic return. In the same line, a trial conducted by KVK Banka in which daily production of 75 kg hydroponic maize and wheat green fodders from 52.5 sq ft tray area was recorded. On day 14, 1.89 kg maize and 1.10 kg wheat green fodder/ ft^2 area were harvested. The height of maize and wheat green fodders were 20-23 cm and 15-17 cm, respectively. Each kg of maize and wheat grains produced 5.7 kg and 4.4 kg fodder, respectively. The milk production of the dairy cattle was also increased by 5% and the cost of per kg milk production was reduced from ₹13.30 to ₹12.70. After feeding of hydroponic fodders, the animals became regular in heat after 2 months of parturition and most of the animals conceived in first or second oestrous cycle. An increment of net profit of ₹25.50/animal/day was recorded by the farm woman. The present case study may be a pathway for its large-scale adoption by the small holder farmers for sustainable dairy farming. Seventeen dairy farmers are following the low-cost hydroponic green fodder production and two automatic hydroponic system were installed at KVK banka and Uparama village of Banka district.

SUMMARY

Production of green fodder intercropping with potato, on bund of pond, mango orchard provides round the year green fodder to small and marginal farmer. Use of non-conventional green fodder was helpful in providing green fodder to marginal and landless farmers. Production of hydroponic fodder under low-cost management can be an alternative to traditional fodder production.

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Improved agro-technique for makhana cultivation

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Makhana is mainly cultivated in North Bihar, mainly Seemanchal area. It has good health benefits, many medicinal values and most common dry fruit which has low or negligible fat content, but rich in protein, carbohydrates and minerals. It is used for milk-based food preparations like kheer, pudding etc. To enhance its economic significance, standard agro-techniques such as improved varieties (viz. Sabour Makhana 1, Swarna Vaidehi), climate and cultivating system, integrated nutrient management (INM), harvesting techniques, and post-harvest packages are necessary to the farmers in order to realize potential yield and achieve better returns. The yield of improved varieties ranges from 28-30 q/ha and pop recovery from 50-55%.

Keywords: Makhana, Bihar, Foxnut

MAKHANA or Gorgan nut or fox nut (*Euryale ferox*) is a most popular, ceremonial and unique product of Eastern India particularly Bihar. It grows well in stagnant water (4-6 months duration) with water depth of 0.5 to 1.2 m and even in the shallow ponds. It is native of South-East Asia continents particularly India and China. At present, the crop is commercially cultivated in several countries of the world. In India, it is cultivated mainly in North Bihar, West Bengal and some parts of Assam. Bihar is the leading state of makhana producing state contributing 85% of the total India's production. It is considered as cash crop and is marketed in the form of popped makhana, commonly known as Makhana pop (lawa). In Bihar, its cultivation is concentrated in seemanchal (Koshi) region encompassing 10 districts of Bihar (Table 1). This district has vast area under water stagnation for 6-7 months in a year with varying depth of water table. It is the fifth agricultural produce from Bihar which received the GI tag due to its specific climatic condition. It helps farmers to get the maximum price of their produce.

Makhana is an exclusively self-pollinated plant in which fertilization takes place at an early stage of their development. Its flower is epigynous, produces bright purple flowers having more than 40 corolla, ovary (7-16) chambered with 6 - 8 seeds/locule. It has industrial demands as a source of high-quality starch for textile industries especially for coating *Banarasi sarees* and silk cloths which contain quality fabrics and starch has appreciable amount of amino acid. The expanded and popped kernels are used in almost all the Vedic oblation and other religious rituals. Despite the unique properties of makhana, the consumers have lack of information about the product and its various uses. Transportation plays a vital role in the supply chain of makhana, a commercially produced product primarily

Table 1. The district wise area, production and productivity of makhana

District	Area (ha)	Production (Mt)	Productivity (t/ha)
Darbhanga	3534	7421.40	2.10
Madhubani	3467	7280.70	2.10
Sitamarhi	146	277.40	1.90
Purnea	5549	11652.90	2.10
Katihar	6143	12900.30	2.10
Saharsa	2549	5352.90	2.10
Supaul	2468	5182.80	2.10
Madhepura	1461	2907.29	1.99
Araria	1427	2639.95	1.85
Kishanganj	1143	2000.25	1.75
	27887	57,615.99	20.09

in north Bihar. The demand for makhana across the country creates opportunities for local wholesalers and other agents to benefit by transporting it to distant markets. The makhana's price in these remote markets is generally 60-70% higher than the local market, making transportation a significant value-addition to the product. Due to its bulkiness, makhana requires more space compared to grains, even for smaller quantities. In the local market, makhana is normally sold at rates ranging from 350-500 per kg depending upon grading size, but once it reaches metropolitan markets, its price significantly jumps to 700 per kg or more, reflecting the increased demand and the importance of transportation in connecting supply with demand across regions.

Health and nutritional value

Makhana pop has enormous health benefits and most common dry fruits which has low or negligible fat content, but rich in protein, carbohydrates and minerals. It is used for milk-based food preparations like kheer, puddings and pulses-based curry, snacks. *Euryale ferox* has been reported for various pharmacological activities comprising anti-diabetic, anti-melanogenic, anti-hyperlipidemic, hepatoprotective, immune-modulatory and anti-cytotoxicity action. Due to presence of dietary fibre, it is also good for constipation and is considered to be an effective food for controlling blood pressure, blood sugar, heart diseases, and anaemia. Traditionally, it is used for the treatment of diabetic nephropathy, enuresis, chronic diarrhea, and dysfunction of the liver. The kernel powder is used in different kinds of ayurvedic medicines to strengthen the spleen and kidneys. It is a gluten-free food, rich in folate that helps in the development of a baby during the first trimester of pregnancy and has also been found to be effective for women at the post-natal stage. The calorific value of raw seeds and puffed seeds is 328 kcal/100g and 362 kcal/100g respectively. Nutritional studies indicates that edible portion of the seed contains 12.8% moisture, 9.7% protein, 0.1% fat, 76.9% carbohydrate, 0.5% mineral contents and 1.45% iron in addition to a good fraction of sugar, phenol and ascorbic acid. Amino acid index is higher than that of staple foods, which indicates its unique food quality. Foxnut possess a superior nutritional profile relative to other dry fruits such as walnut, almond, cashew nut or coconut in contents of sugar, proteins, phenol and ascorbic acid.

Improved agro-techniques

The Kosi region of Bihar is naturally waterlogged, not only in ponds but also in low-lying cultivable areas, making it suitable for cultivation in field conditions. To enhance its economic significance, standard agro-techniques such as improved varieties, climate and cultivating system, integrated nutrient management (INM), harvesting techniques, and post-harvest packages are necessary to the farmers in order to realize potential yield and achieve better returns.

Varieties

Sabour Makhana-1: This variety is selection from the local by BAU, Sabour and released by the State Varietal Release Committee of Bihar during 2016. It exhibits distinctive features such as large spherical leaves, dark purple flowers, medium-sized fruits, and small oval seeds with an incredibly thin seed coat (0.29 mm) having potential yield of 32-35 q/ha with high-quality makhana pop recovery (55-60%).

Swarna Vaidehi: This variety has been developed by ICAR-RCER, Patna, and released by State Varietal Release Committee during 2013 for Bihar, Assam, Chhattisgarh and Odisha. It thrives in stagnant perennial water bodies, including ponds, land depressions, oxbow lakes, swamps, and ditches. It exhibits a remarkable production potential of 28-30 q/ha having 42-48% makhana pop recovery rate. It is commercially cultivated in North Bihar, Manipur, parts of West Bengal, and Madhya Pradesh.

At present, these varieties are under cultivation in large areas by progressive farmers and cooperative groups located in Darbhanga, Purnea, Madhubani, Katihar, and Sitamarhi) of Bihar and gaining valuable experience in its cultivation.

Table 2. Comparison of Sabour Makhana1, Swarn Vaidehi and Local Variety

Particular	Sabour Makhana-1	Swarn Vaidehi	Local Variety
Seed rate(kg/ha)			
i. Transplanting	22-25	25-30	45-50
ii. Direct sowing	40-45	42-47	80-90
Sowing time	December-January	December-January	December-January
Germination %	90-95	90-92	70-75
Plant growth	Vigorous	Vigorous	Less vigorous
Disease/Pest incidence	Moderate	Moderate	Susceptible
Water depth (m)			
i) In field condition	0.3 to 0.5	0.3 to 0.5	0.3 to 0.5
ii) In pond condition	1.2-1.5 or more	1.2-1.5 or more	1.2-1.5 or more
Yield (q/ha)	32-35	28-30	16-18
Pop recovery %	55-60	40-41	35-40
Cost of cultivation (₹/ha)	1,19,017	1,20,017	98,490
Gross return (₹/ha)	3,73,800	3,70,800	2,00,100

Climate and morphology

Makhana is an important aquatic herb with gigantic leaves of 1-2 m size, thorny and floating in water. The upper surface of leaves is green and lower side is purple with 0.90 to 1.5 m long petiole. It is normally grown in tropical and subtropical climates in stagnant water of 0.2-2 m depth. It requires temperature in the range of 20 to 35°C; relative humidity of 50- 90% and annual rainfall of 100-250 cm for proper growth and development with water transparency of 50%.

Whole makhana fruit (left); Cross section of makhana fruit showing seeds (right)

Crop cultivation

- **Pond system:** It is very old method of cultivation maintaining water depth of 1.5-2 m. There is no need of seed sowing in old pond but in new pond, seeds are sown by broadcasting method @ 80 kg/ha during December-January. This system gives low yield and it is very tedious and cumbersome to harvest kernel from the bottom of the pond. It takes one year to complete the crop cycle.
- **Field/farming system:** It is a modern method of makhana farming requiring less time and water maintaining 30-60 cm water depth. Intercropping is possible with fodder in same year. It requires nursery for raising 2-3 months seedlings having 4-5 leaves, light green in colour which are suitable for transplanting in main field at the spacing of 1.25 m × 1.25 m during 4th week of March- 1st week of April. Crop diversification can be made by growing different water crops like water chestnut, fish, particularly catfishes, sweet flag along with makhana cultivation.

Integrated nutrient management

Cultivating Makhana in the region requires slightly higher doses of micronutrients (copper and zinc) as Zn plays a crucial role in flowering, fruit growth and seed formation. The application of NPK and FYM, in combination, enhances the yield of Makhana. Makhana exhibits a favourable response to FYM application as compared to NPK fertilizers, hence right quantity (dose) of farmyard manure (FYM) is considered crucial as it also provides traces of micro-nutrients elements. For obtaining higher yield of Makhana under field conditions, 20 t/ha FYM and NPK @100:60:40 kg/ha as a basal application in the pond between February and March was found most effective. Full dose of phosphorus, potassium and FYM and half dose of nitrogen, along with 30 kg of lime should be applied at the time of final land preparation about 5 days before transplanting while remaining half nitrogen is applied in 2-3 equal parts, starting at 20-25 days of transplanting.

Insect-pest management

The most prevalent insect is mollusca, aphid (*Rhopalosiphum nymphaeae* L.), caseworms (*Elophila depunctalis* W. & *E. crisonalis* W.) and rib borer (*Chironomous spp*.) that causes 17.04% to 23.67% loss in seed yield. To control this insect-pest, root deep treatment for 30 min with Imidacloprid and Thiamethoxam @ 5 g/l before sowing followed by spraying of 5% neem oil 40 days after planting and repeat at 25 days of interval effectively manages the crop.

Weed management

The aquatic weeds need to be kept under controlled condition especially during early stages of plant growth after transplanting, as these compete with the main crop for nutrients, water, light and space growth of makhana leaves. Depending on weed infestation intensity, at least 2-3 hand weeding are necessary at 15-20 days interval starting from early stage (25-30 days after transplanting) to till the water surface covered by large spherical makhana leaves. Once, water surface completely covered by large spherical makhana leaves, the growth of weeds is suppressed. *Euryale ferox* has been reported for various pharmacological activities comprising antidiabetic, anti-melanogenic, antihyperlipidemic etc.

Harvesting and yield

In pond system, harvesting required experienced farmer for picking matured makhana kernels from bottom of the pond which is very labour intensive. This is done with the help of a horn shaped bamboo pole, locally known as the 'Kaara'. Later on, the mud is sieved through a locally made bamboo screen or sieve known as the 'Ganiya'. The yield of makhana seed range from 22 to 30 quintals per hectare depending upon the variety. In field system, makhana harvesting is less labour intensive and less risky with higher seed yield collection in comparison to pond system.

Seed processing

The seeds (gudi) cannot be consumed directly and need to undergo manual processing to become 'pop' or popped makhana. The processing involves several steps, including cleaning, grading, sun drying, preheating, roasting, popping, and polishing. The value of makhana significantly increases after this processing steps that

Harvesting of makhana seed

transforms a raw seed to a popped makhana. Initially, farmers sell the raw makhana seeds to processors at a price of approximately ₹ 90-120/kg. The conversion ratio of one kilogram of seed to popped makhana is about 30-40%, which means that from one kilogram of raw seed, nearly 350-400g of popped makhana are obtained. The popped makhana is sold at a higher price, usually around ₹ 250-400 per kilogram. Consequently, the value of the makhana is nearly doubled after it undergoes the transformation from seed to pop.

Processing of pop

Makhana pops are consumed in their raw form, but several companies in India are enhancing their appeal by adding value through the incorporation of various flavours such as onion, chili, pudina, cream, and other spices. These flavoured makhana pops undergo roasting and are then packaged in small packets similar to other snakes/chips, making them convenient for marketing and sale. Thus value addition allows the makhana pops to be marketed as a delightful and ready-to-eat snack option, making them increasingly popular among consumers.

Grading and sorting

Local wholesalers receive makhana from processors hailing from various regions, and this makhana is a mix of different pop sizes. The sorting process is carried out either manually or by using a makhana grader at the warehouses of the local wholesalers. The size grading is crucial as the market value of the makhana varies directly with the size of the pop. Larger-sized pops had higher prices in the market due to their increased demand and appeal to consumers.

Challenges

Foxnut farmers are experiencing a lack of skilled workforce on the ground. Workers need to spend hours in water to cultivate and harvest foxnut. But it is difficult to find skilled workers in the area. Weed management and proper harvesting are two crucial steps in foxnut farming. Every step is labour intensive and we need to spend a lot of time and energy on these steps.

Sabour makana-1 variety holds significant potential, especially in waterlogged areas that have been historically overlooked and underutilized. By cultivating Sabour Makhana-1, farmers can reliaze from higher net returns without depleting natural resources.

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Contribution of KVKs in State Policy

Kerala

- KVK Pattanamthitta has been declared as the State Resource Centre for Jackfruit value-addition based on the pilot programme on jackfruit based entrepreneurship promotion by the KVK
- KVK Alapuzzha is the State Resource Centre for agro-processing and value-addition

Lakshadweep

- After Sikkim, Lakshadweep islands has been declared organic and the large area organic certification is done by the KVK

Maharashtra

- Farm pond has become a State Level Programme

Bihar

- 38 districts are now being covered with Climate Resilient Agriculture (CRA) policy
- NARI has been integrated with the Nutri-garden along with Anganwadi programme (18000 centres)

Jharkhand

- Bora bandi technology for soil and water conservation has been undertaken by the Jharkhand Government to diversify rice-vegetable cropping system in ~500 villages

West Bengal

- Land shaping technology in Sunderbans increased cropping intensity to 270% and income upto Rs. 4 Lakhs/ha from Rs. 30 thousand. Technology was multiplied in 2000 hectares and attracted investment (Rs. 30 crores) from State Government

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Millet recipe contest: A community engagement model

for exploring the millet diversity in Jharkhand

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Jharkhand boasts of diverse agro-climatic zones, spanning from hilly terrain to plains. Millets, characterized by their adaptability to various ecological conditions, thrive in different parts of the state. These small-seeded grasses, cultivated for millennia worldwide, are hardy crops resilient to harsh conditions like drought and poor soil fertility. Despite their suitability for diverse climates, millet cultivation has dwindled among Jharkhand's indigenous communities over the past few decades. This decline, coupled with persistent issues of food security and malnutrition, particularly in tribal areas, presents an ongoing challenge. Addressing the dual crisis of biodiversity loss and nutritional security requires tapping into the traditional wisdom of local communities and promoting indigenous crops. The inclusion of millets in the food system becomes crucial for a holistic nutritional approach amid the challenges posed by climate change. In line with the International Year of Millets, aiming to generate domestic and global demand while reintegrating millets into the common diet, the Krishi Vigyan Kendra Ranchi, under the auspices of ICAT-ATARI Patna, has organized a series of recipe contests among rural and farm women in Ranchi district. Participating in millet-based recipe contests, for the village women, presents a unique opportunity to celebrate their rich agricultural heritage and incorporate locally grown millets into their daily lives. These contests not only showcase the diverse culinary traditions of the region but also empower villagers to embrace sustainable and nutritious food choices. By participating in these contests, farm women can share their traditional knowledge of millets, fostering a sense of community and cultural pride. This initiative aims to explore the rich biodiversity of millets and enhance practices related to growing and consuming millets among the local population. In a state where agriculture plays a crucial role in the livelihoods of many, promoting millet cultivation and consumption through millet-based contests can contribute to the economic well-being of local farmers.

Keywords: Biodiversity, Jharkhand, Krishi Vigyan Kendra, Millet, Recipe

NUTRITIONAL security and food security are interconnected concepts that are vital for the well-being of individuals, communities, and nations. India food security is mainly dependent on current staple foods rice and wheat, which are not sufficient to overcome the challenges. The recent publication by the Lancet Commissions recognize the importance of identifying healthy and environmentally sustainable diet like millet which are known for their resilience to climate change and their rich nutritional content. Interestingly, the paper highlights that out of the 14,000 edible plants available; only three crops viz. rice, maize, and wheat contribute to 60% of our calorie intake. On the other hand, the SDGs 2030 aim to eliminate all forms of malnutrition by 2030. To achieve this ambitious goal, it is crucial to intervene and replace a significant portion of our current diet, which heavily relies on rice, wheat, and maize, with highly nutritious grains like millets.

Millets have a significant connection to Jharkhand, both historically and in the present context. It has been a traditional food crop in Jharkhand for generations. Millets are known for their adaptability to different

ecological conditions, making them suitable for cultivation in various parts of the state. But millet cultivation has been steadily declining since India's Green Revolution in the 1960s, and has come close to near abandonment over the course of the last few decades among Jharkhand's Indigenous communities. According to the National Family Health Survey (NFHS-5), as of 2019-21, 56.8% of pregnant women and 67.5% children in Jharkhand under five years are anaemic. This dual crisis of biodiversity loss and nutritional security can be addressed through the traditional wisdom of local communities and indigenous crops. It is crucial to promote the inclusion of millets in the food system to ensure a more holistic approach to nutrition in the face of climate change.

In order to enhance the practices of growing and consuming millet crops, under the guidance of ICAR-ATARI Patna, Zone IV, KVK Ranchi has organized 3 recipe contest among rural and farm women of Ranchi district with the following objectives– (a) to explore and document the millet diversity in various food preparations, (b) to assess the awareness and knowledge of the nutritional benefits of millets among the local population, (c) to study the traditional uses, and their significance in local culture and (d) to promote their consumption for better health and sustainable agriculture.

Implementation of the programme

The Millet Recipe contest program was conducted in three purposively selected villages namely Gutru (Burmu block), Soso and Khaksitoli (Angara block). Village selection was done on the basis of quantum of millet cultivation and diversified millet diets by the population. The program was done in two phases as mentioned below:

- **Pilot survey:** As part of the programme, a comprehensive survey covering a representative sample of households was conducted by using approved questionnaire provided by Indian council of Agricultural Research (ICAR), New Delhi to assess the cultivation practices and consumption patterns of millets. The survey was done 15 days prior to competition in the selected villages. Rural and farm women were gathered at a common place as they were priorly informed about the meeting from KVK. Information was recorded by one-to-one interaction. In this program, they were made aware about health benefits of millet such as it regulates blood sugar, supports digestive health, and provides essential nutrient for overall well-being, and they were suggested to create a millet-based value-added food so that they could learn about the different food processing techniques on millet crops.

Community engagement through recipe competition

- *Planning and preparation:* On mutual consensus, a suitable date and venue for the contest was decided in the village premises at community centre to accommodate participants and spectators. A written formal consent was also taken prior to organization of the event from the concerned authority.

A view of millet recipe competition at Gutru village

- *Establishment of collaboration and linkage:* The KVK scientists remained in touch with the with rural institutions (NGOs, Panchayat, Schools, Aganwadi) to gain support and resources.
- *Promotion of the contest*: The awareness was created by various social media platforms like posters on community bulletin boards, partnership with local markets, and educational institutions as well as advisement through local newspapers, radio stations channels for coverage.
- *Event execution:* The event coordinated by the Head of the KVK along with participatory team of scientists with other stakeholders like Gaon Burhas, Anganwadi Head, School headmaster, Pacnchayat members to execute the contest. Rural women were mobilized in a participatory manner to demonstrate their culinary creativities in making traditional foods using the best possible options from indigenous biodiversity of millet. A simple on the spot registration was done for all the participants including details like name, contact information, and the type of millet dish they brought.
- *Judging and evaluation:* A local committee involving five prominent experts, like VDO, Gram pradhan,

scientist from KVK Ranchi, experts from IFFCO, and local leaders evaluated the dishes. The participants' recipes were evaluated on 9 points for seven different parameters such as appearance, taste, texture, flavour, creativity, ease of preparation, and overall acceptability. The scores for each quality were total and averaged. The top five winners from each contest were declared based on the judges' scores. Throughout the competition, every detail regarding their dish, including the components used, the preparation process, the mode of consumption, etc were recorded and the recipe contest scorecard was also assessed.

- *Awards and recognition:* At the end of event, prizes were distributed on the basis of the scores awarded for different parameters along with knowledge variability on cooking and processing. The top five winners from each contest were declared based on the overall scores. The chief guest of the program presented the prizes and a certificate of achievement to the winners.

Judging and prize distribution during the contest

- *Documentation:* The various recipes were compiled under different categories into traditional millet recipes, innovative millet dishes, and desserts. Winner's stories were also documented behind each recipe, highlighting the cultural significance and personal connections to millets. The media coverage during and after the event was also done and pictures, videos, and participant interviews were also shared on social media and local news outlets.
- *Follow-up:* The feedback from participants and attendees were also collected to improve future events. The winners were further studied in greater details and taken as biodiversity ambassadors for the promotion of millets as wonder crops in village level planning on biodiversity conservation led adaptation programmes.

Outcomes of the programme

The millet recipe contest was conducted in the Gutru, Soso and Khaksitoli villages on 23rd August, 3rd October, and 28th October, 2023 respectively. The event saw the enthusiastic participation of more than 100 rural farm women. In each village, participants prepared and showcased up to 45-50 types of (conventional and contemporary processed) food using millets as a major ingredient such as *roti, ladoo, sev, dhuska, idli, pakodas,* and many more. The major findings of the study are discussed below.

Total land under millet cultivation

In terms of cultivable land for millets, it was observed that in Gutru village, almost 50% of farmers are growing millets in 40 to 80 dismil (Table 1). Similarly, in Soso village, maximum farmers (43.9%) are growing millets in 40 to 80 dismil. Whereas in Khaksitoli village, more than 60% of farmers are growing millets in > 80 dismil area. This leads us to the fact that more than half of the farmers cultivating millets are medium or semi-medium category and the rest half fall into the category of marginal or small farmers.

Table 1. Land (Dismil) under millet cultivation

Land for millets	Gutru	Soso	Khaksitoli
<40 dismil	26.7%	33.2%	12.0%
40-80 dismil	49.6%	43.9%	27.2%
>81 dismil	23.7%	22.9%	60.8%

Millet based traditional food knowledge

Each region has its own traditional food habits. Traditional foods are those which are locally accessible by indigenous communities and can be prepare by utilizing their traditional knowledge in the natural environment. This survey results demonstrated that 100% of rural and farm women from selected villages have knowledge about their millet based traditional foods. Specifically, *Madua Chilka and Dhuska* routinely prepared by 80% women, 10% making *laddoo, gatha* and 10% making *halwa, sev* etc.

Diversity in use of millet

In millet crop, ragi (*Finger millet*) is one of the major crops also known as '*Madua*' in local language holding significant importance as a traditional millet crop in rainfed farming system of Jharkhand state. In order to rejuvenate the consumption of finger millet in the daily diet of tribal individuals in the state, a wider range of recipes that cater to their preferences adding diversity and value to the specific dietary needs of the population is required.

Table 2. Diversity in use of millet

Range	Gutru	Soso	Khaksitoli
2-4 varieties	24%	23%	59%
4-6 varieties	64%	68%	34%
>6 varieties	12%	9%	7%

This data represents the distribution of responses across different ranges of varieties of use of *Madua* for three selected villages: Gutru, Soso, and Khaksitoli. Each row corresponds to a specific range, and the percentages indicate the proportion of each category within that range.

All three selected villages show millets are predominantly consumed as a staple food, diverse millet-based recipes are popular within households. In Gutru and Soso village, maximum population i.e 64% and 68% respectively, use *Madua* in 4-6 variety of dishes whereas in Khaksitoli, maximum 59% population use *Madua* for making 2-4 variety of dishes.

Varieties of millet-based recipes presented during the contest

Cultural significance of millet

Millets are culturally embedded within Jharkhand's indigenous communities which play a significant role in various cultural rituals associated with birth to death and honouring ancestors. This survey study resulted in 100% of women using *Madua* grain on some specific occasion. Maximum (90%) population use millet specifically *Madua* in *Karma* and *Jitiya* festivals whiles other (10%) use it in *Sarhul puja*.

Status of habitat conservation of millets

The conservation of millets involves seed collection, multiplication, seed distribution and farmer-to-farmer exchange mediated through the traditional seed storage system. In this study, it was found that in all three villages, majority of population (60%) produce millet in their field and conserve them through traditional approach for future production.

Source of knowledge about learning

This study revealed that rural and farm women perceived information about millet cultivation and processing from both formal and informal sources like SHG members, family member, neighbours, local leaders, KVK training, TV, Radio, social media etc. In all three selected villages, maximum (80%) villagers get millet related information from Krishi Vigyan Kendra (KVK) through training program, kisan mela, exhibitions etc. Nearly 10% villagers perceived information from TV, mobile and social networking sites and 10% from other sources like family or neighbouring members, SHG group.

Traditional food knowledge from native place

As per the data collected, 80% of the women learnt *Madua* roti from their native place, 10% of them learnt Chilka and Gatha and 10% learnt ladoo/barfi/halwa/sev from their houses.

Membership of indigenous institutions

As per our survey, 85% of women were part of one or the other indigenous institutions such as JSLPS, *Maa Santoshi Mahila Samiti, Nari Vikash Yojana, Kisan Vikash Mahila Samiti* and many more.

Habitat/Conservation of millets

In Gutru, Soso and Khaksitoli village, about 60% of farmers produce millet in their field and 40% of them buy from markets.

SUMMARY

Millets, well-suited to Jharkhand's climate, can become a staple crop, providing resilience against environmental challenges and ensuring food security for communities. The emphasis on millet-based recipes aligns with the need for sustainable agriculture in Jharkhand becomes a platform not just for cooking skills but also for preserving and passing down culinary wisdom from one generation to the next. Encouraging the cultivation and consumption of millets can have positive implications for the environment and the overall well-being of Jharkhand's villagers. In conclusion, millet-based recipe contests in Jharkhand go beyond the kitchen; they represent a celebration of cultural heritage, a boost to local economies, and a step towards sustainable living. Embracing millets in everyday cooking can foster a stronger connection to the land, promote health, and contribute to the resilience of rural communities in Jharkhand.

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Journey of natural farming

The pathway towards sustainable agriculture

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This article provides a precise explanation of the necessity of natural farming. Over time, advancements in farming technology have addressed the immediate needs of hunger and poverty. However, the long-term repercussions on the environment and humanity are not favourable. Hence, there is a growing recognition for a more sustainable and ecological lifestyle, commonly referred to as natural farming. The increasing global popularity of natural farming can be attributed to its numerous environmental and social benefits. By using less chemical pesticides and fertilizers, soil and water pollution is reduced, biodiversity is preserved, and the effects of climate change are mitigated. Realizing the potential of natural farming, some countries, including India, have recently taken steps to promote its adoption. Natural farming has several advantages, yet there are still barriers to its widespread adoption.

Keywords: Cow dung, Green revolution, Natural farming, Soil fertility, Sustainable agriculture

INDIA once possessed a self-sufficient socio-economic model in the pre-British era. However, colonization by the British and Western policies had a profound impact on India's agriculture. In 1943, during World War II, the Bengal region faced a severe drought, leading to a policy failure that resulted in the loss of 30 lakh lives due to starvation in colonized India.

The struggle for Indian independence was marked by significant challenges. In 1951, during the first population census, India had a population of 36.11 crore, with grain production at 50.82 million metric tonnes. This output proved inadequate to meet the nation's food requirements. To address this shortfall, Indian leaders decided to expand agricultural land by clearing forests. Despite some improvements in grain production through the five-year action plan, it remained insufficient to meet the hunger needs of the population. In response, India sought assistance from the USA, signing Public Law 480 (PL 480) agreements to acquire low-quality wheat at market prices.

Globally, agriculture is the fundamental industry for feeding humanity. In 1960, American scientist Norman Borlaug made groundbreaking contributions to farming, introducing concepts like the use of high yielding varieties (HYV), fertilizers, and pesticides. He developed short-straw, high-yielding wheat varieties from the Japanese Norin 10 and the Mexican PV 18 local variety. Recognizing the efficiency of this technology, Dr. M. S. Swaminathan endorsed it to meet India's agricultural needs.

In 1965, India faced a war crisis with a neighbouring country, coupled with international pressure and restricted sanctions threatening to halt supplies under PL 480. In this challenging situation, India's strong political leadership rallied the nation with the slogan "Jai Jawan, Jai Kisan," marking the inception of the real Indian Green Revolution.

Green revolution

Under the guidance of the Indian Council of Agricultural Research and Dr. M. S. Swaminathan, the Government of India initiated efforts to develop high yielding varieties, encouraged use of fertilizer, introduced pesticides, promoted mechanization, and enhanced irrigation facilites. A scientist from Punjab, Mr. Athwal, identified a variety named Kalyan, and ICAR combined it with another variety called Sona, which resulted in the high-performing Kalyan-Sona. The Indian government extended subsidies on various facets was crucial for the Green Revolution.

The positive outcomes were notable, with crop yields soaring to 131 million metric tonnes in 1978. Within a decade, India transitioned from being an importer to becoming an exporter. Even during the severe drought faced by Maharashtra in 1972, not a single case of starvation-related casualties was reported, showcasing

the revolution's impact on food security. However, as the saying goes, "every coin has two sides," the Green Revolution also brought about adverse effects on ecology and human well-being.

Impact of the Green Revolution

The Green Revolution primarily targeted wheat and rice production in states like Punjab, Haryana, and Uttar Pradesh, bringing about significant changes in crop yields. Farmers in these regions experienced increased yields through the application of more fertilizers. However, the excessive use of fertilizers made the soil alkaline, which resulted in a loss of soil fertility.

In the Punjab region, the use of pesticides reached approximately 923 g/ha in 2011, which was 353 g/ha higher than the national average. This extensive use of pesticides had severe implications on the health of the local population. Notably, the region gained notoriety for the 'cancer train' running between Bhatinda and Bikaner, underscoring the adverse health impacts. The Bhopal tragedy in 1984 serves as a poignant example of the direct and negative consequences of the chemical-intensive practices associated with the Green Revolution. The incident underscores the potential hazards and risks posed by the widespread use of such chemicals in agricultural practices.

Organic farming

In response to the adverse effects of the Green Revolution, a solution known as organic farming has been advocated. This environmentally friendly approach is considered safer than conventional farming. It involves utilizing inputs such as organic waste, cow dung, green manuring, bio enzymes, and some mechanical operations, which are not only less costly than chemical inputs but also contribute to sustainable agriculture. However, it demands more time and effort.

One challenge of organic farming is the need for a substantial amount of organic matter, requiring the maintenance of a large number of animals to generate organic waste. Additionally, inoculating bacterial cultures and using diesel or fuel for mechanical operations entail capital investments that may be beyond the means of small or marginal farmers. Despite growing awareness of the benefits of organic products, distinguishing genuine ones can be challenging. This difficulty arises from the fact that plants absorb nutrients in inorganic forms. Nutrients in organic sources remain unavailable for crop use until the material undergoes decomposition, releasing its nutrients into the inorganic soil pool.

Natural farming

Natural farming is an ecological farming approach established by Masanobu Fukuoka (1913 to 2008), a Japanese farmer and philosopher. Natural methods of farming respect life, maintain natural laws, and apply natural products. Natural farming includes earthworms, microorganisms, and small creatures and it intends to have a positive impact on the environment. Natural farming restores soil damage caused by chemicals and equipment. Natural farming products offer a pleasant taste, superior quality, and higher yields and have high nutritional content. The very essence of the term suggests that nature takes care of the farming process. This method requires minimal external inputs, with just one indigenous cow being sufficient for nearly 30 acres of land.

Renowned natural farming advocate Padmashree Mr. Subhash Palekar emphasized that hybrid seeds are more responsive to chemical fertilizers and pesticides, but their responsiveness diminishes over time with increased use. In contrast, indigenous seeds exhibit high responsiveness to natural farming practices, resulting in more productive, nutrient-rich, and healthier crops compared to hybrid seeds. Mr. Palekar asserts that Basmati Rice production using chemical fertilizers reaches only 12 quintals per acre, while natural farming can elevate it to 18 quintals per acre. Similar benefits are expected for Bansi wheat in the Madhya Pradesh region.

Table 1. State-wise area and farmers under natural farming (2022-23)

State	Area (in ha)	No. of practicing farmers
Andhra Pradesh	290000	630000
Bihar	132	137
Gujarat	186000	432000
Haryana	7931	2992
Himachal Pradesh	50000	159000
Jammu and Kashmir	12120	3850
Jharkhand	50	40
Karnataka	2000	4400
Kerala	82000	326000
Madhya Pradesh	111000	59071
Maharashtra	74000	82000
Odisha	24000	27009
Punjab	2217	1853
Rajasthan	9000	171000
Tamil Nadu	2000	2360
Telangana	2403	2002
Uttar Pradesh	97460	105000
Total	952313	2008714

Source: https://naturalfarming.dac.gov.in/NaturalFarming/ImplementationProcess

During 2022-23, as per the data released by the Department of Agriculture & Farmers Welfare, the total area under natural farming in India is 9.5 lakh hectares in 17 states. The total number of farmers practicing natural farming within these states is estimated to be 20.08 lakhs. The highest area under natural farming has been reported from Andhra Pradesh (2.9 lakh hectares) followed by Gujarat (1.86 lakh hectares) and Madhya Pradesh (1.11 lakh hectares).

Components of natural farming

Natural farming is based on four key pillars described below:

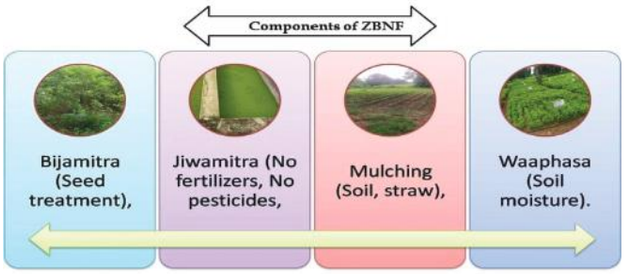

Figure1: Different components of Zero Budget Natural Farming

Jivamrita: Jivamrita is a fermented mixture of cow dung, urine, jaggery, pulse flour, water, and farm bund soil, used to improve soil fertility. It is not a fertilizer but a source of 500 million microorganisms that convert nutrients from their 'non-available' state into their 'available' one.

Benefits of jivamrita

- Higher growth rates in plants
- Higher level of palatability
- Higher profitability and production of sustainable crops boost the crop's absorption and concentration of nutrients

Bijamrita: The process includes the treatment of seed using cow dung, urine, and lime-based formulations. Used as a seed treatment solution before sowing.

Benefits of bijamrita

- It promotes the growth of plants
- Protects the crops from harmful seed-borne and soil-borne pathogens
- Improve the pH level of soil
- Increases earthworm count in the soil

Whapasa: The process involves activating earthworms in the soil to create water vapour condensation.

Benefits of whapasa

- Improves soil aeration, humus content, water availability, capacity to retain water
- Improve soil structure

Mulching: A microclimate is created using mulches with trees and crop biomass to maintain soil moisture and maintain a temperature range of 25-32°C for survival of microorganisms.

Benefits of mulching

- Improves soil drainage and structure as it decomposes
- Improves soil conditions
- Stops nutrients from leaching out of the soil

Status of natural farming in India

Department of Agriculture and Farmers Welfare, Government of India has sanctioned a project titled 'Outscaling of Natural farming through 425 KVKs'. The Indian Council of Agricultural Research has

implemented the project through 11 Agricultural Technology Application Research Institutes (ATARIs) in 425 KVKs of the country. Under the project, KVKs are carrying out the activities like awareness campaigns, training programmes and demonstrations on natural farming as per the targets given to them. ATARI wise targeted activities for KVKs during 2022-23 and 2023-24 is given in Table 1.

Several states implemented natural farming, Andhra Pradesh, Chhattisgarh, Kerala, Gujarat, Himachal Pradesh, Jharkhand, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh, and Tamil Nadu are prominent among them. Through a variety of programs, state governments in several states are encouraging natural farming practices at the ground level.

Andhra Pradesh

The government of Andhra Pradesh has adopted a natural farming system based on ecology instead of input economics. Its main approach is that it reduces synthetic inputs, provides cost-effectiveness as well, and improves environmental conditions, making it climate-resilient and less expensive.

Gujarat

Additional financial support was provided in the Budget 2020-21 under the Gujarat Atma Nirbhar package to promote natural farming. Additionally, on 17 September 2020, the Gujarat government developed two programs namely Sat Pagala Pastoral Welfare and Pagala for natural farming.

Table 2. ATARI wise targeted activities for KVKs during 2022-23 and 2023-24

Name of ATARI	State/ Union territory	KVKs under Project	No of training pro-grammes	No. of demon-strations
Ludhiana	Punjab, Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Leh-Ladakh	42	840	1008
Jodhpur	Haryana, Rajasthan, Delhi	38	760	912
Kanpur	Uttar Pradesh	52	1040	1248
Patna	Bihar, Jharkhand	39	780	936
Kolkata	Odisha, West Bengal, Andaman and Nicobar Islands	34	680	816
Guwahati	Assam, Arunachal Pradesh, Sikkim	27	540	648
Barapani	Manipur, Nagaland, Mizoram, Tripura, Meghalaya	25	500	600
Pune	Maharashtra, Gujrat, Goa	48	960	1152
Jabalpur	Chhattisgarh, Madhya Pradesh	48	960	1152
Hyderabad	Andhra Pradesh, Telangana, Tamil Nadu, Puducherry	44	880	1056
Bengaluru	Karnataka, Kerala, Lakshadweep	28	560	672
	Total	425	8500	10200

Himachal Pradesh

Himachal Pradesh practices natural farming under the *Prakrit Kheti Khushal Kisan* (PK3) scheme. The main objective of this scheme is to reduce the cost of cultivation and increase the income of the farmers. This scheme was announced by the Chief Minister in the budget speech of 2018-19. The scheme aims to increase food grain, vegetable, and fruit output without using artificial fertilizers or pesticides.

Rajasthan

In the budget statement for the financial year 2019-20, the Hon'ble Chief Minister of Rajasthan expressed his support for natural farming through an initiative-*Kheti Mein Jaan Toh Sashakt Kisan*, which reduced input costs and empowered farmers through profitable farming. The initiative, first launched as a pilot project, covers Tonk, Sirohi, and Banswada in three districts of the state. Under the programme, expert trainers from the department led two-day sessions in which 18,313 farmers were trained.

SUMMARY

One of the compelling aspects of natural farming is the minimal input costs for farmers, accompanied by no harm to nature or human health. This approach creates a win-win situation. In a world with increasing awareness of the detrimental effects of excessive chemical use, products cultivated through natural means are in high demand, commanding premium prices in the market. Natural farming is gaining popularity due to its emphasis on organic methods, low external inputs, and ecological balance. It offers a potential substitute for traditional farming and can lead to sustainable agriculture and food security. However, to fully realize its potential, several challenges need to be addressed, including access to organic inputs, efficient certification, and beneficial marketing and distribution networks. Collaboration between farmers, governments, educational institutions, and consumers is crucial to tap the potential of natural farming in India. Investments in research, capacity building, and infrastructure development can help facilitate the adoption of natural farming techniques across the country.

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New initiatives undertaken by KVKs at National Level

- Promotion of Natural Farming in 425 districts
- Application and promotion of agri-drone across the country
- Involvement in International project (ICAR-CSISA Collaborative project) for obtaining feedback regarding technology adoption and development of strategies for upscaling and outscaling
- ICT led interactive technology information dissemination through Kisan Sarathi
- Special project on Cotton under Cotton Mission in 100 districts and Millets based interventions for popularization of millets
- Promotion of FPOs by KVKs as CBBOs, technology backstopping and handholding
- Linkage with CSCs (3.5 lakhs) for last mile extension delivery

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Application of drone technology for

sustainable agriculture in western India

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The most advanced aspect of automation of agriculture is precision agriculture. Precision agriculture has become essential due to its potential and applications. Smart agriculture encompasses various technologies and practices, including smart irrigation, drones, remote sensing, and mapping. These tools can greatly enhance farming operations and address the challenges faced by farmers. Agricultural drones have come to the aid of farmers and have made farming easier and more efficient. Using drones in smart farming not only makes farming more accurate but also can help become people farm smart. Among agricultural drones, the performance of spraying drones is very impressive and reliable. This article includes information on the potential utilization of drones in agricultural practices (spraying, crop monitoring and crop surveillance), adoption of drone technology by various implementing centres under ICAR-ATARI Pune Zone, information on drone pilot training, and progress of demonstration. Drone technology has a prominent position in assisting farmers with more efficient decision-making and automating agricultural processes. This could help overcome some of the adoption barriers faced by farmers in less economically advantaged regions.

Keywords: Agri-drone, Unmanned aerial vehicles (UAVs), Custom hiring centres (CHCs), KVKs

THE majority of rural households continue to rely on agriculture as their main source of income. India's economy is also mostly dependent on agricultural produce which includes a major portion of its exports as well. Nearly 56% of the population depends upon the agriculture sector for their livelihood. In India, about 44% of the cultivated land is taken care of by small and marginal farmers, who contribute to almost 60% of the total food grain production. It has consistently stood as the pivotal economic sector in India, assuming a strategic role in the nation's economic development. Crop failure due to adverse weather conditions and uncontrolled pest issues have been the key contributors to this scenario. Moreover, Indian farmers are even now dependent on monsoon rains for irrigation and use of old methods for other farming practices. As a result, despite farmers' tireless efforts, the quality and quantity of agricultural produce are sometimes compromised. To address the food demands of a rising human population, agricultural practices have integrated a growing number of technologies to increase crop yield and reduce operative expenditure. As a result, the increasing use of 'smart technologies,' such as artificial intelligence and automated machinery, has been incorporated into various stages of food production, from crop planting and livestock guarding to food processing and transport. At present time, when the farming sector is facing several challenges, including labour shortage and falling incomes, the use of Unmanned Aerial Vehicles (UAVs), popularly known as drones, has come to the rescue of farmers to aid them in various activities including spraying of pesticides, and nutrients management.

Drone improves efficiency by reducing workload and time required in numerous industries. The progressive automation of agricultural processes has significantly improved the productivity of agricultural labour, shifting masses of workers into other productive industrial areas.

With the advancement of technology, the research on drones has become more and more in-depth, and the practical application fields have become more extensive. The unparalleled advantages of these 'smart technologies' also play an important role in their incorporation into various stages of food production. At present, drone technology has also gradually matured.

The application of drones in agriculture is already widespread across Asia and other parts of the world. Their usages are limited and specific for commercial

operations in horticulture, agriculture, and forestry. Spraying for weeds, insect-pests, and disease management, spreading fertilizers as well as planting new forests are the diverse uses now being found for drones.

Potential application of drone technology in agriculture

Crop spraying: The technology was first implemented in Japan in the 1980s when unmanned helicopters equipped with spraying equipment and pesticide tanks were used to spray crop fields. Typical modern-day spraying drones have a tank capacity of over 10 litres of liquid pesticide with a discharge rate of over a litre a minute, allowing them to cover a ha in 10 minutes. Drones can carry reservoirs of suitable size, which can be filled with fertilizers, herbicides, or pesticides for spraying on crops in large areas in a relatively shorter time. Crop spraying is much safer and cost-effective because of its autonomous and pre-programmed run on specific schedules and routes. Drones are also programmed to self-adjust their altitude and speed using ultrasonic echoing, time-of-flight (TOF) lasers and Global Navigation Satellite System (GNSS) signals to achieve uniform and optimum spraying results across varying topography. Smart farms are using drones for agriculture spraying, which reduces human contact with harmful chemicals such as fertilizers and pesticides. Drones are also unparalleled when it comes to spot treatment automated with stress detection technology, which uses sensors and cameras to treat affected areas while leaving the healthy parts intact. Drones enhance spraying capacity up to five times faster than traditional machinery.

Crop monitoring: Crop monitoring is the biggest headache not only for farmers but also for various other stakeholders associated with agriculture operations. This challenge has also gotten worse with the rise of unpredictable weather patterns, which lead to rising crop loss risks and maintenance costs. Drones can be used to set monitoring routes by gathering multispectral geospatial and temporal datasets at pre-defined scales that relate to crop development. Data analytics help in getting insights on crop health much before being visible by manual field scouting.

Crop surveillance: It is nearly impossible to estimate the overall state of crops in large fields. Agricultural mapping using drones can help farmers stay updated on the status of their plants and identify the areas of the fields that require attention. Drones equipped with infrared cameras can inspect the fields and estimate the state of crops based on their light absorption rates. With accurate real-time information, farmers can take necessary measures to improve the health of crops in any spot of the field. This crop surveillance and health assessment feature of drones also forms the basis of using them to enhance agricultural insurance tools for cross-verifying farmers' insurance claims. However, financial implications *vis-a-vis* the insurance model adopted and practical possibilities will decide the future potential use.

In the crop insurance scheme, *Pradhan Mantri Fasal Bima Yojana* (PMFBY) of the Government of India, crop yield estimation at the lowest specified administrative level is considered the most important indicator for deciding insurance claims. For crop yield estimation, the well-established methodology of crop cutting experiments (CCE) has been in use so far, to evaluate and validate a large number of pilot studies carried out in different parts of the country.

Financial assistance

The Union Ministry of Agriculture and Farmers Welfare has issued guidelines to make drone technology affordable to the stakeholders in a major boost to promote precision farming in India. The ICAR, New Delhi had approved various State Agricultural Universities (SAUs), Krishi Vigyan Kendras (KVKs) and ICAR Institutions for allocation of funds for the purchase of drones and demonstrations during 2022-23.

To provide agricultural services through drone application, financial assistance @ 40% of the basic cost of the drone and its attachments or ₹ 4 lakhs, whichever is less is also provided for drone purchase by existing and new Custom Hiring Centers (CHCs) under Cooperative Society of Farmers, Farmers Producer Organizations (FPOs) and rural entrepreneurs. The agriculture graduates establishing CHCs are eligible to receive financial assistance @ 50% of the cost of a drone up to a maximum of ₹ 5.00 lakhs. In addition to the already identified institutions for drone demonstration, other agricultural institutions of the state and central government, and central public sector undertakings engaged in agricultural activities have also been brought to the eligibility list for financial assistance for farmers' drone demonstration.

Agri-Drone project in ATARI Pune

ATARI Pune Zone-VIII covers the states of Maharashtra, Gujarat and Goa comprising 82 KVKs; of which 50, 30 and 2 exist in the respective states. Ministry of Agriculture under the Agri Drone Project of Sub Mission on Agricultural Mechanization has sanctioned 40 drones in the year 2022-23, 7 to State Agricultural Universities, 23 to ICAR Institutes and 10 to Krishi Vigyan Kendras.

Drone pilot training in ATARI Pune

Directorate General of Civil Aviation (DGCA) has authorised 63 Remote Pilot Training Organizations (RPTO) in the country. RPTO centres have been approved by DGCA for providing drone pilot training and skilling across the country. ATARI Pune organised pilot training for the implementing centres at 3 RPTOs viz. MPKV, Rahuri, Maharashtra; Rashtriya Raksha University, Gandhinagar, Gujarat and Centre for Aerospace, Chennai, Tamil Nadu. In RPTO MPKV, Rahuri, Maharashtra, 35 remote pilots trained from 3 agricultural universities, 9 ICAR institutes, and 6 KVKs. In RPTO RRU, Gandhinagar, Gujarat, 22 drone pilots were trained from 4 agricultural universities, 1 ICAR

institute and 5 KVKs. Two drone pilots from ICAR-NIASM, Baramati were trained at Centre for Aerospace Chennai, Tamil Nadu.

Table 1. RPTO centre-wise distribution of implementing centre

Name of RPTO	Name of implementing center	No. of drone pilot trained
MPKV Rahuri, Maharashtra	MPKV Rahuri, PDKV Akola, VNMKV Parbhani, ICAR-CICR Nagpur, ICAR-CCRI Nagpur, ICAR-CIFE Mumbai, ICAR-DOGR Pune, ICAR-NRCG Pune, ICAR-NRCP Solapur, ICAR-NBSS&LUP Nagpur, ICAR-DFR Pune, ICAR-CCARI Goa, KVK North Goa, KVK Jalna-I, KVK Dhule, KVK Yavatmal-I, KVK Pune-II and KVK Kolhapur-II	35
RRU Gandhinagar, Gujarat	AAU Anand, JAU Junagadh, SDAU Dantiwada, NAU Navsari, ICAR-DGR Junagadh, KVK Ahmedabad, KVK Navsari, KVK Kheda, KVK Panchamahal and KVK Junagadh	22
RPTO, MIT, Tamil Nadu University Chennai, Tamil Nadu	ICAR-NIASM, Baramati	2
Total	29	59

Demonstrations conducted in ATARI Pune

Implementing centres (29) conducted 1,149 drone demonstrations on 569.25 ha area on different crops by KVKs, ICAR research institute, and Agricultural Universities field for benefiting 6,638 farmers. Demonstrations were conducted on various fruit crops, vegetables, pulses and other field crops.

Table 2. Demonstrations under Agri-Drone project

Category of implementing centre	No. of kisan drones sanctioned	No. of kisan drone demonstration organized	Area covered (ha)	Number of farmers who participated
Agriculture Universities	07	34	27.45	632
ICAR Institutes	23	118	120	1324
KVKs	10	997	421.80	4682
Total	40	1149	569.25	6638

Constraints/Problems encountered during drone demonstration

- Under windy or rainy conditions, flying drones is not easy, unlike traditional aircraft. Drones are weather-dependent.
- Maximum time lost for identifying four corners of the field while operating the drone in autonomous mode.
- The drone requires two people for their operation,

Drone demonstration on nano-urea foliar application, farmer's sensitization and enhancing productivity in sugarcane

Demonstration on spraying of gram

Demonstration on spraying of PGR for fruit crop

Demonstration on spraying of pesticides on onion

therefore, requires a dedicated team to be available for the planning and execution of drone demonstrations.

SUMMARY

Drone technology has a lot of potential for efficiently carrying out a variety of agricultural tasks. The modern youth are not attracted towards farming due to the hard work and drudgery involved in it. The implications of drones may fascinate and encourage the youth towards agriculture, as drones enable farmers to have a better understanding of their fields. With the help of drones, farmers can produce more food while using fewer chemicals. Almost all farmers who have made use of drones have achieved some form of benefit. They can make more efficient use of their land, exterminate pests before they destroy entire crops, adjust the soil quality to improve growth in problem areas, improve irrigation for plants suffering from heat stress and track fires before they get out of control. Therefore, drones may become a major part of agriculture in the future by helping farmers manage their fields and resources in a better and sustainable way. But high initial costs and policy reforms are two difficult obstacles to overcome, to make it popular and farmer-friendly. Despite the limitations, these tools and technology are expanding rapidly with their use in agriculture by providing information about farming.

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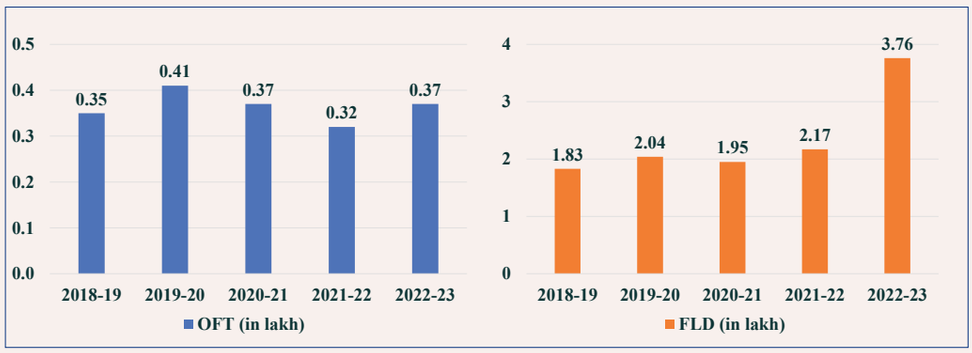
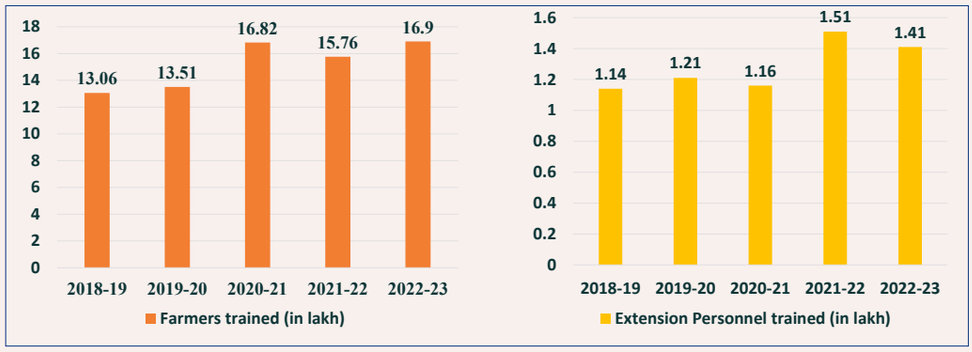
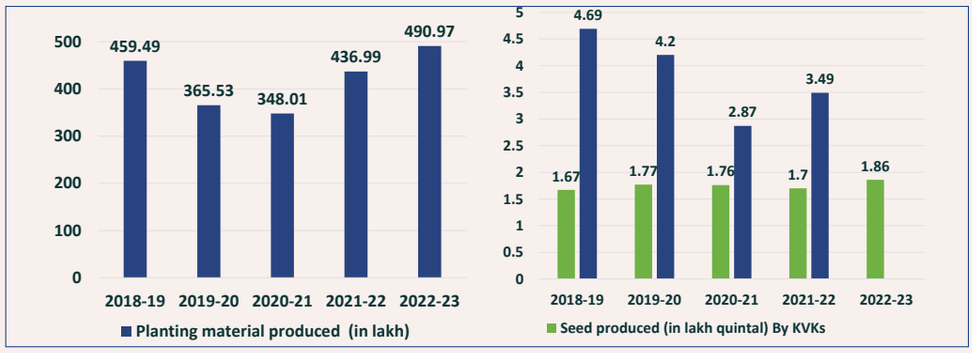
Outreach Programmes of KVKs (2018-19 to 2022-23)



Training Activities of KVKs (2018-19 to 2022-23)



Seed and Planting Materials by KVKs (2018-19 to 2022-23)



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Harmony in cultivation

Expanding the reach of natural farming practices

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In recent decades, the indiscriminate use of natural resources in Indian agriculture has resulted in environmental, social, and economic challenges for the planet Earth. Natural farming has emerged as a beacon of hope in modern agriculture, offering a sustainable alternative to conventional farming practices. In recent years, the importance of natural farming has garnered widespread attention due to its potential to address pressing challenges. At its core, natural farming emphasizes working in tandem with nature's rhythms rather than against them. By harnessing the inherent resilience and complexity of natural ecosystems, this approach seeks to nurture healthy soils, enhance biodiversity, and promote the well-being of farmers and communities. Recognizing the significance of natural farming, ICAR initiated a nationwide project titled 'Out-scaling of Natural Farming through KVKs, in 2022. In ATARI Zone-IX, the project is being implemented across 48 KVKs in Madhya Pradesh and Chhattisgarh to promote and expand the adoption of natural farming practices via Krishi Vigyan Kendras. Within this initiative, the crucial components focused are promoting natural farming practices, capacity building for farmers, demonstrations and trials, scaling up, and knowledge sharing and documentation of natural farming practices.

Keywords: Capacity building, Chhattisgarh, Demonstrations, Krishi Vigyan Kendra, Madhya Pradesh

As the world population continues to grow rapidly, the demand for food is increasing accordingly. To meet this rising demand sustainably, it is imperative to transition towards sustainable agriculture practices. The excessive use of chemicals and fertilizers has led to the rapid deterioration of soil fertility, posing significant environmental risks. Synthetic fertilizers and pesticides are not only polluting the environment but also contributing to soil degradation. Natural farming offers a sustainable and resilient approach to agriculture, aligning with principles of ecological balance and biodiversity conservation. In natural farming, practices such as ploughing and tilling of soil are eliminated, and synthetic fertilizers are replaced with natural alternatives. Farm-made pesticides derived from natural sources are utilized to control pests and diseases, promoting healthier ecosystems and soil fertility. Natural farming represents a chemical-free agricultural system deeply rooted in Indian tradition, enriched with modern ecological insights, resource recycling, and on-farm resource optimization. It embodies an agro-ecology-based diversified farming system that seamlessly integrates crops, trees, and livestock with functional biodiversity. Central to natural farming is the on-farm recycling of biomass, emphasizing practices such as biomass mulching, the use of on-farm cow dung-urine formulations, and the maintenance of soil aeration. An essential aspect of natural farming is the exclusion of all synthetic chemical inputs, promoting sustainable and environmentally friendly agricultural practices.

Adoption of natural farming

ICAR is spearheading a nationwide initiative titled 'Out-scaling Natural Farming through Krishi Vigyan Kendras' across 425 districts in India. Natural farming is practiced in several states, with prominent adoption observed in Andhra Pradesh, Chhattisgarh, Kerala, Gujarat, Himachal Pradesh, Jharkhand, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh, and Tamil Nadu. Currently, approximately 6.5 lakh hectares of land are covered under natural farming in India. This approach aims to reduce dependency on purchased inputs, offering a cost-effective farming solution with potential for enhancing employment and rural development. Total 48 KVKs were allotted for implementing the natural farming during the 2022-23, 16 KVKs were allotted

from Chhattisgarh state while 32 KVKs from Madhya Pradesh. Natural farming prioritizes the restoration of soil health, maintenance of biodiversity, ensuring animal welfare, efficient utilization of natural and local resources, and promoting ecological fairness.

Key practices essential for the adoption of natural farming includes avoidance of external inputs, utilization of local seeds, emphasizing the use of indigenous varieties, application of on-farm produced microbial formulations (such as bijamrita) for seed treatment, incorporation of on-farm made microbial inoculants (such as jivamrita) to enrich the soil, implementation of cover crops and mulching using green and dry organic matter to recycle nutrients and create a conducive microclimate for beneficial microbial activity in the soil, adoption of mixed cropping practices, promotion of farm diversity through the integration of trees, pest management through utilization of local on-farm made botanical concoctions (like neemastra, agniastra, neem ark, dashparni ark, etc.), integration of livestock (particularly native breeds) for the utilization of cow dung and cow urine as essential inputs for various practices and emphasis on water and moisture conservation techniques.

Objectives

The objectives of the project 'Out-scaling of Natural Farming through Krishi Vigyan Kendra' are promoting the widespread adoption of natural farming practices across India, eliminating or minimizing the use of chemical fertilizers and pesticides in agriculture, encouraging the utilization of locally available resources for nutrient management and pest control, enhancing the economic viability of farming by reducing production costs and increasing farmers' net incomes, improving agricultural productivity and overall farm profitability, building resilience to climate change and environmental degradation in agriculture, popularizing integrated farming approaches that incorporate sustainable agriculture and animal husbandry practices, facilitating knowledge dissemination and capacity building among farmers to adopt natural farming techniques effectively, collaborating with stakeholders including farmers, agricultural experts, and policymakers to promote sustainable agriculture practices, and contributing to environmental sustainability by reducing greenhouse gas emissions and preserving natural resources.

Major components of natural farming

- Beejamrit, an ancient and sustainable agricultural technique, is utilized for treating seeds, seedlings, or any planting material. This fermented microbial solution is rich in plant-beneficial microbes and is applied as a seed treatment to protect young roots from fungal infections. By colonizing the roots and leaves of germinating seeds, the beneficial microbes in beejamrit contribute to the healthy growth of plants, promoting their vigour and resilience.
- Jivamrit, serves as a biostimulant by stimulating the activity of microorganisms in the soil and enhancing the activity of phyllospheric microorganisms when applied to foliage. It functions as a primer for microbial activity, initiating and supporting the growth of beneficial microbial communities in the soil and on plant surfaces. Additionally, Jivamrit contributes to the proliferation of native earthworm populations, further enriching the soil ecosystem and promoting soil health.
- Mulching is the practice of covering the soil surface with a layer of material, which can include live crops or straw (dead plant biomass). This technique serves multiple purposes, including the conservation of moisture by reducing evaporation, moderation of soil temperature around plant roots, prevention of soil erosion by wind or water, reduction of runoff during rainfall events, and suppression of weed growth by blocking sunlight and hindering weed seed germination. Residue mulching also saves seeds from birds, insects, and animals. Overall, mulching is a valuable practice for promoting soil health, water conservation, and weed management.
- Whapasa refers to the mixture of 50% air and 50% water vapour present in the pore spaces between soil particles. This microclimate within the soil is crucial for soil organisms and plant roots, as it provides the primary source of moisture and some nutrients. It plays a vital role in increasing water availability within the soil, thereby enhancing water-use efficiency for plants. Additionally, it contributes to building resilience against drought conditions by maintaining adequate moisture levels in the root zone. Overall, Whapasa is essential for supporting soil health and promoting optimal plant growth and productivity.
- Plant protection involves the application of biological concoctions through spraying, aimed at preventing pest, disease, and weed problems while simultaneously enhancing soil fertility and plant health. Various formulations are utilized for plant protection measures, including Neemastra, Brahmastra, Agnistra, Dashaparni Ark, or Kashaya. These concoctions are composed of natural ingredients and are applied to plants to deter pests and diseases, thereby reducing reliance on synthetic pesticides and herbicides. Additionally, they contribute to improving soil health and fertility, fostering a balanced and sustainable agricultural ecosystem.

Initiatives/Programmes to create mass awareness cum capacity building of personnel involved in natural farming

- National Workshop on Natural Farming organized at RVSKVV, Gwalior on Dec 3, 2022.
- Regional Workshop on Natural Farming organized by KVK Burhanpur, Madhya Pradesh on 27-28 March 2023.
- Regional Workshop on 'Chemical Free Natural Farming in the Present Context: Challenges and Prospects' held on 9-10 October 2022 at KVK Satna.
- National Conference on 'Next Generation

Agriculture Organic and Natural Farming Pathways: Extension Strategies & Approaches' held on January 28-30, 2024 at ICAR-ATARI, Jabalpur.

Overall, initiatives and programs focused on creating mass awareness and building the capacity of personnel play a vital role in promoting the adoption of natural farming. By empowering farmers with knowledge and skills and engaging stakeholders across the agricultural sector, these initiatives contribute to the widespread adoption of sustainable farming practices and the achievement of broader goals related to food security, environmental sustainability, and rural development.

Success stories of farmers in natural farming

India is leading the way by adopting natural farming practices, guided by Krishi Vigyan Kendras (KVKs) and inspired by the promise of healthy soils and bountiful harvests, these farmers are witnessing firsthand the economic and ecological benefits of natural farming. In the quest for sustainable agriculture, progressive farmers across various parts of Madhya Pradesh and Chhattisgarh are embracing natural farming practices and witnessing remarkable transformations in their agricultural landscapes. Here, we delve into some inspiring success stories that showcase the power and potential of natural farming in fostering resilient, eco-

Success Story

From soil to success: Journey with natural farming

Mohan Gangaram Patel, a farmer from Lohari village, Khandwa, Madhya Pradesh, has achieved success in natural farming with the support of Krishi Vigyan Kendra. Despite his limited education and landholding, he embraced KVK's assistance, transitioning to natural farming practices. With guidance, he focused on cultivating Chickpea Var. RVG 204 over 0.40 hectares, showcasing the effectiveness of natural techniques like seed treatment with beejamrit and manual weeding. This shift led to a notable increase in yield from 16.25 to 21.25 quintals per hectare, significantly boosting income. Mohan's success underscores the benefits of jeevamrit and amritpani application, reducing dependency on costly inputs. While facing challenges like labour availability, his story highlights the viability of natural farming. Recommending the replication of such models among other farmers, it suggests exploring high-value crops and establishing markets for naturally produced goods, fostering sustainability and economic growth.

Success Story

Leading the green revolution in Burhanpur with natural farming

In the district of Burhanpur, Madhya Pradesh, farmer Prabhakar Sitaram Chaudhary has emerged as a torchbearer of sustainable agriculture, showcasing the process of natural farming. Engaging with the Krishi Vigyan Kendra during 2022-2023, he embarked on a journey that not only transformed his yields but also revolutionized his approach to farming. A medium landholding farmer with a three-hectare plot, two indigenous cows, and a high school education, he implemented innovative interventions such as jivamrut, bijamrut, nimastra, bramhastra, and dashparni ark at regular intervals.

Under the natural farming paradigm, he cultivated gram (RVG-203) on 0.4 hectares, achieving a commendable production of 14.1 q/ha. The KVK played a pivotal role, providing training, capacity building, and essential inputs for the demonstrations. A careful comparison between natural farming and conventional farming practices revealed remarkable success. While natural farming incurred a lower cost of cultivation at ₹37,950, this resulted in a higher net income of ₹25,590 and a better benefit-cost ratio of 1.67, signifying the economic viability of natural farming. The success story extends beyond financial metrics. Prabhakar attests to the reduction in fertilizer and insecticide costs, praising the environmental and economic benefits of natural farming. Despite facing challenges related to manual labour for input preparation and application, he recognizes the potential for further expansion of natural farming in his fields. The story culminates with a vision for the future as Chaudhary plans to extend the adoption of natural farming to other crops, making him a beacon of sustainable agriculture in the region.

Through scientific practices and institutional support, Prabhakar Sitaram Chaudhary has not only transformed his farming techniques but has also sown the seeds of a greener, more sustainable future for agriculture in Burhanpur.

Success Story

Restoring soil health in Chhattisgarh

Deepak Kumar, a farmer from Chhattisgarh's Bhatapara district, embarked on a transformative journey into natural farming during 2022-2023. Guided by the Krishi Vigyan Kendra (KVK) in Baloda Bazar (Balod), Deepak implemented a comprehensive set of farming practices on his two hectare landholding. His interventions included the application of various natural inputs like beejamrit, ghanjeewamrit, jeewamrit, mulching, and plant protection methods using neemashtra, agniashtra, brahmashtra, and mixed leaf extracts. Focusing particularly on Chickpea variety RVG-202, covering 0.40 hectares, Deepak achieved a production yield of 4.76 quintals.

Deepak's venture into natural farming not only resulted in a healthy crop but also reflected positively on the economic performance of his farm. The adoption of these practices led to a lower cost of cultivation compared to conventional farming methods, reducing operational expenses significantly. Despite a slightly lower yield, the net income increased notably, alongside a favourable benefit-cost ratio.

His success highlights the viability and sustainability of natural farming practices, bringing economic benefits while contributing to soil health and organic matter improvement. With a commitment to continue natural farming with the support of KVK, Deepak's experience stands as an inspiring model for fellow farmers seeking cost-effective and environmentally friendly agricultural solutions.

friendly, and prosperous farming communities.

SUMMARY

Natural farming emerges as a promising and sustainable agricultural approach with multifaceted benefits. Through its emphasis on organic inputs, minimal chemical usage, and holistic ecosystem management, natural farming not only enhances soil health and fertility but also promotes biodiversity and reduces environmental degradation. The success stories presented underscore the viability of natural farming, with higher yields, lower costs, and improved profitability compared to conventional farming practices. These success stories exemplify the transformative potential of natural farming in revitalizing agricultural systems by rejuvenating soil health, increasing crop yields, and empowering farming communities. As we navigate the challenges of climate change, resource depletion, and food insecurity, the adoption of natural farming practices offers a pathway towards a more sustainable and resilient future for agriculture. Through the guidance and support of Krishi Vigyan Kendras/ ATARIs, farmers across India are embracing sustainable agricultural practices and reaping the rewards. By celebrating these successes and sharing their lessons, we can inspire more farmers to embrace the principles of natural farming and contribute to building a healthier, more vibrant planet for generations to come.

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Overview of underutilized horticultural crops

in North-Eastern region

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The study discusses the rich biodiversity and potential of underutilized horticultural crops in the North-eastern region of India. The region, covering only 7.7% of India's total geographic area, is home to more than 50% of the country's biodiversity, with over 60% of the region's crops being underutilized. The study underscores the importance of these underutilized crops in addressing food security, agrobiodiversity conservation, and a more resilient agricultural system. It also highlights the therapeutic diversity of these crops, their potential for value-addition and post-harvest management, and their significance in traditional medicine systems. The significance of these underutilized crops in addressing various health issues and contributing to traditional medicine systems is emphasized, along with their potential for income generation for local farmers and sustainable agricultural practices. Additionally, the study addresses the pivotal role of Krishi Vigyan Kendras (KVKs) in fostering awareness among farmers regarding the importance and conservation of these crops.

Keywords: KVKs, Therapeutic diversity, Underutilized crops, Value-addition

THE Northeastern region of India, consisting of eight states viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, and Sikkim is located between latitudes 21°51′ and 29°5′ and longitudes 85°5′ and 97°5′ E. The region boasts of its rich biodiversity accommodating a large variety of flora and fauna, and represents an important part of the Eastern Himalaya and Indo-Burma global biodiversity hotspot amongst the 36 recognized global biodiversity hotspots. Northeast region occupying only 7.7% of India's total geographic area, covers more than 50% of the biodiversity in the country, out of which 31.58% is endemic. The tropical and subtropical temperature and alluvial soil of the Brahmaputra and Barak plains, as well as the temperate climate of the hills with laterite and sandy soil, support a diverse range of tropical and temperate horticultural crops having high nutritional value. Apart from the nutritional value, many local horticultural crops are used for medicinal purposes, income generation and poverty alleviation programmes in the rural areas. In 2021, approximately 2.3 billion people were affected by moderate or severe food insecurity due to limited access


Aerial yam


Burmese grapes

to nutritious and affordable food options. Plants play a vital role in securing human nutrition worldwide, comprising about 84% of the human diet. Nonetheless, there is an increasing dependency on a restricted set of crop species for sustenance. Despite the existence of approximately 50,000 edible plant species known to humanity, only a minor fraction, roughly 150 to 200 species, finds utilization as food. Strikingly, a mere 15 crop plants contribute to 90% of the world's food energy intake. From this, over 60% is derived from just three major crops: rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), and maize (*Zea mays* L.). This pattern of reliance creates a concerning trend in our food system, posing challenges for both people and the planet. There are about 800 different species of underutilized edible crops in India, out of which about 300 species are used mostly by the tribal and rural population of the Northeastern region alone. Underutilized crops refer to wild or semi-domesticated plant species that are often overlooked and not fully utilized, despite their considerable potential. These plants have significant untapped benefits but have been largely neglected in agricultural and food systems. These crops are neither extensively cultivated on a commercial scale nor widely traded, primarily these are cultivated, trade a and consumed on a local level. These crops belong to categories such as cereals and pseudocereals, legumes, vegetables, oilseeds, roots and tubers, aromatic and medicinal plants, fruits and nuts, and have earned collective names such as 'neglected and underutilized' or 'forgotten', 'orphan', 'minor' crops. Underutilized species include not just food plants but also many other species— wild or cultivated—used as sources of oil, fuel, fibre, fodder, beverages, stimulants, narcotics, ornamental, aromatic compounds, and medicine. These plants are significant not just for conservation but also for gaining insights into their genetic background and important genes or alleles that favour their survival in harsh environments. They are instrumental in providing food, improving livelihoods, and nutritional coverage for people living in hilly areas. Underutilized crops have the potential to be crucial in resolving the world's ongoing food challenges. They offer sustainability, adaptability, and nutritional value that can contribute to food security, agrobiodiversity conservation, and a more resilient agricultural system and agro-food value chains. Many of these species are incredibly resilient, and their capacity to adapt to challenging growing and climatic conditions holds tremendous promise in the era of climate change. In this context, they are the crops of the future.

Therapeutic diversity of underutilized horticultural crops in NE Region of India

Several wild indigenous fruit crops which are rare in other parts of the world grow favourably and naturally in the foothills track of Eastern Himalayas due to suitable geo-climatic conditions. The horticultural crops in this region encompass a diverse range, including tropical and subtropical fruits, temperate fruits, vegetables, and flowers, comprising both indigenous and introduced varieties. These underutilized crops not only play a pivotal role in bolstering agricultural diversity but also contribute significantly to food security while preserving traditional knowledge. Embraced by indigenous communities, these crops serve dual purposes by not only providing nutritional benefits but also contributing to traditional medicine systems, effectively addressing various health issues such as digestive disorders, inflammation, and respiratory ailments etc. The vast array of underutilized horticultural crops in the Northeastern hills represents a treasure trove with enormous therapeutic potential for a variety of ailments, underscoring the importance of exploring and conserving these valuable species.

Table 1. Therapeutic diversity of underutilized horticultural crops in NE region of India

Common name	Scientific name	Family	Distribution	Plants parts used	Therapeutic utility	Image
Carambola	*Averrhoa carambola*	Oxalidaceae	All north eastern states	Fruit and leaves	Fruit juice is used to counteract fever, lower high blood sugar and high blood pressure, and antidiarrheal effects.	
Burmese grape	*Baccaurea ramiflora* Lour.	Phyllanthaceae	Tripura and Meghalaya	Fruit, bark, leaves	Fruits – to treat skin diseases, improves immunity, decreases severity of cold and flu.	

Table 1. Continued

Common name	Scientific name	Family	Distribution	Plants parts used	Therapeutic utility	Image
Khasi cherry	*Docynia indica*	Rosaceae	Khasi hill (Meghalaya) and Sikkim	Fruit	To treat common ailments. Prophylactic for combating enteric diseases.	
Spine gourd	*Momordica dioica*	Fabaceae	Meghalaya & Mizoram	Fruit and leaves	Treating diabetes, cancer, and neurodegenerative diseases.	
Tamarillo	*Cyphomandra betaccln* Cav.	Solanaccae	Nagaland, Mizoram and Meghalaya	Fruit	Maintains blood pressure, lowers cholesterol levels, helps weight loss and to treat cold, sore throat and headache.	
Roselle	*Hibiscus sabdariffa* L.	Malvaceae	Mizoram & Meghalaya	Leaves and fruit	To treat hypertension and microbial infection.	
Turkey berry	*Solanum torvum* Sw.	Solanaceae	All north eastern ststes	Fruit	To treat fever, wounds, tooth decay, reproductive problems and arterial hypertension and in cases of liver and spleen enlargement.	
Indian pennywort	*Centella asiatic*a L.	Apiaceae	Tripura	Whole plant	Leprosy, kidney trouble, ulcers, body aches, asthma, gastric, catarrh, elephantis.	
Vegetable fern	*Diplazium esculentum* (Retz.) Sw.	Athyriaceae	Nagaland & Meghalaya	Leaves	To treat diabetes, smallpox, asthama, diarrhea, rheumatism and wounds.	

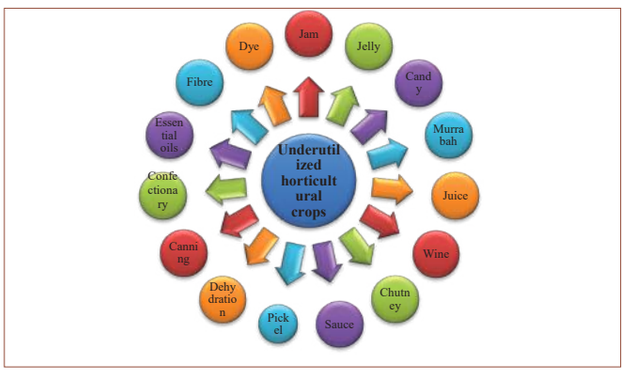
Table 1. Concluded

Common name	Scientific name	Family	Distribution	Plants parts used	Therapeutic utility	Image
Chameleon plant/ fish mint	*Houttuynia cordata Thunb*	Saururaceae	All north eastern ststes	Root, shoot and leaves	Treatment of cholera, dysentery, curing of blood deficiency and purification of blood.	
Sugandh-mantri	*Homalomena aromatica (Spreng.) Schott*	Araceae (Herb)	Tripura	Stem, leaves, root	To treat cold and cough, jaundice, stomach, and skin problems.	
Elephants foot yam	*Amorphophallus paeonii-folius*	Araceae	Tripura and Meghalaya	Stem, leaves, tuber	Tuber paste is applied externally to treat piles, toothache and rheumatism.	
Aerial yam	*Dioscorea bulbifera* L.	Dioscoreaceae	All north-eastern states	Tuber	To treat worms, piles and dysentery and to kill hair lices.	

Diversity of underutilized horticultural crops in terms of value-addition and post-harvest management

The untapped potential of indigenous and lesser-known horticultural crops in the region remains underutilized, despite their ability to address issues of poverty, food insecurity, and nutritional deficiencies through processing, value addition, and diverse applications. These fruits and vegetables boast high levels of vitamins and minerals, along with valuable secondary metabolites and medicinal properties that can be harnessed for industrial and medicinal purposes. Additionally, these underexplored crops exhibit resilience in adverse environmental conditions. Farmers in the Northeast are well-informed about these crops and their medicinal benefits, often using them to treat various ailments. Nevertheless, these crops are predominantly cultivated in backyard gardens or forested areas and are yet to be commercially grown. The various value-added products, such as jam, jelly, pickles, wine sauce, chutney, etc., and commercial products including essential oils, fibre, and dye, can be prepared from these underutilized horticultural crops. This provides an opportunity to boost income for local farmers and promotes sustainable agricultural practices.

Value-added products from underutilized horticultural crops



Source: Deka *et al.* 2012 and Barua *et al.* 2019

Table 2. Underutilized horticultural crops utilized for different value-added products

Underutilized crop	Products
Carambola	Pickle, juice, jam and jelly
Burmese grape	Jam and jelly
Khasi cherry	Fresh, juice, jam, jelly, wine
Tamarillo	Jam, pickle
Roselle	Jam from fruits, pickle from leaves
Elephants foot yam	Pickles, dried cubes, chips, thickening agents

Way forward : KVKs' perspective

- KVKs can play important role in exploring, identifying, characterizing, conserving, and safeguarding the germplasm of underutilized crops available in their agroclimatic region. It is imperative to initiate strategies for collaborating with research organizations for standardizing technologies for crop improvement, value-addition, processing, and the production of secondary metabolites.
- Underutilized horticultural crops are predominantly cultivated and managed within traditional farming systems by diverse ethnic communities. There is a heightened need to focus on documentation of indigenous knowledge associated with underutilized horticultural crops by thorough ethnobotanical studies. KVKs have a major role to facilitate in harnessing of improved value addition technologies to create the opportunities for secondary agriculture in NER by using a significant portion of native diversity for multipurpose uses.
- KVKs at the micro level may take the initiative for strategic intervention through 4P partnerships involving the public, private, producer and policy for creating incentive-based improved and expanded cultivation of underutilized horticultural crops among farmers for providing multipurpose benefits to farmers.
- To address the escalating demand for underutilized crops in the near future, it is imperative that KVKs play a significant role to raise awareness among urban populations regarding the nutritive values of these crops and the necessity to establish a lucrative market for them.

SUMMARY

The Northeastern region of India is a biodiversity hotspot, housing numerous underutilized horticultural crops with high nutritional and medicinal value. These crops, often neglected, have the potential to address food challenges, contribute to food security, and create a more resilient agricultural system. KVKs can play a vital role in conserving indigenous knowledge, collaborating with research organizations, promoting cultivation, and raising awareness about the nutritive value of these crops to benefit farmers and create a profitable market.

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Impact of climate resilient technologies

in Chittoor district of Andhra Pradesh

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Indian agriculture, heavily reliant on monsoons, faces climate sensitivity, with fluctuations in rainfall and temperature significantly impacting crop productivity and threatening food security. Recognizing this challenge, the Indian Council of Agricultural Research (ICAR) launched the National Innovations in Climate Resilient Agriculture (NICRA) programme in 2010-11. NICRA aims to make villages climate-proof by providing site-specific technological demonstrations to enhance farmers' adaptive capacity in climatically vulnerable districts. Implemented by KVK, Chittoor (RASS), the NICRA project in Chittecherla and Deendarlapalli villages in Andhra Pradesh from 2015 to 2021 focused on enhancing agriculture and allied sectors' resilience to climate vulnerabilities through improved production and risk management technologies. As part of this initiative, eleven community irrigation tanks in the villages were renovated to improve surface water storage and groundwater recharge, ensuring water availability for crops over a larger area. Recharging 129 bore wells near the tanks by 3 feet benefitted 242 farmers. The adoption of resilient technologies led to notable increases in yield: paddy by 11.5%, groundnut by 15.8-38%, tomato by 11.6-24.5%, and mango by 12.7%. These climate-resilient practices have played a significant role in mitigating the adverse effects of climatic aberrations in the NICRA cluster villages over the years.

Keywords: Climate, Irrigation, NICRA, Productivity, Resilience, Yield

Implementation of the project

NICRA project was implemented in Chittecherla and Deendarlaaplli villages in Chinnagottigallu mandal in the erstwhile Chittoor district during 2015-2021. The climate is hot at the time of summer season and moderate during winter season. The majority of the soils are red loam and red sands. About 350 farm families are in the village and most of them are small and marginal farmers. The agriculture mainly depend on rains and irrigation under tanks and bore wells. The major crops grown are paddy, groundnut, tomato and mango and farmers depend mostly on dairy activity. The cluster villages received less than normal rainfall, i.e. 770 mm and experiences severe drought situation. The main objective of NICRA project is to motivate the farming community to utilize the available resources effectively and efficiently through conservation of soil and water besides imparting technical skills to improve productivity and livestock management.

Natural resource management: Under this module, interventions related to rain water harvesting, soil and water conservation, green manuring, supplemental irrigation and recharge of bore wells were taken up in the cluster villages.

Renovation of community irrigation tanks

Clearing of unwanted vegetation and deepening of the tanks (11 nos.), strengthening of tank bunds and desilting activities were carried out under NRM activity with community participation. This helped in increasing the water storage capacity (8,721 cu.m) of the tanks and increased ground-water recharge in the bore wells (129 no.) in the vicinity and crops were cultivated in an area of 201 ha which benefited 242 farmers in the cluster villages. Feeder channels were also cleared of vegetation and deepened to improve flow of rain water to the tanks.

Direct sown rice in harvest stage

Govindarajula cheruvu filled with rain water after renovation

Conservation of soil moisture in tomato by using polythene mulch

The KVK conducted demonstrations on the use of polythene mulch with drip irrigation system in tomato for four years (2015-19) with an objective of soil moisture conservation, weed control at critical stages of crop growth and to improve productivity. Polythene mulch of 25 micron thickness was spread over a raised bed on which holes of 4-5 cm diameter were punched with recommended spacing of 90 x 30 cm of tomato (Sweekar 448 variety).

Polythene mulch was effective in conserving soil moisture as the number of irrigations used in farmers practice (without mulch) was 27 during entire crop period while it was only 17 in case of demonstration (with polythene mulch). Weed density was low (41.8/m^2) with polythene mulch in tomato than without mulch (59.5/m^2), since it prevents weed seed germination and physically suppress seedling emergence. About 24.5% increase in fruit yield (69,481 kg/ha) was recorded under polythene mulch when compared to without mulching (55,780 kg/ha). More cost of cultivation (₹20,875 per ha) in the demonstration was due to polythene mulch and it was compensated by achieving higher fruit yield. More net returns, ₹25,311 per ha was recorded with polythene mulch than without mulch (₹2,03,913 per ha). At present, this technology is used by the farmers not only in tomato but other crops also like musk melon, papaya, mango and other vegetable and flower crops in the district in an area of more than 500 ha.

Green manuring in mango for yield improvement

The existing practice is to keep mango orchard interspaces vacant, which resulted in more weed growth, loss of nutrients and fertile soil due to erosion. Hence RASS KVK motivated farmers to adopt green manuring in mango orchards and conducted 200 demonstrations in the cluster villages from 2015-16 to 2018-19. Sunhemp (*Crotalaria juncea*) seed was supplied to the farmers and the same was sown @ 50 kg per ha in the mango orchards. The sunhemp crop was ploughed into soil at flowering stage, which resulted in improved physical and chemical properties of the soil, thereby contributing to higher yield.

Green manuring resulted in 12.7% increase in mango fruit yield (8,605 kg/ha) when compared to farmers practice (7,570 kg/ha). Improvement in fruit yield may be due to balanced nutrient management as green manuring enriched soil with major and micro nutrients and also due to negligible weed growth. At present this technology is disseminated and adopted by farmers in an area of more than 600 ha.

Supplemental irrigation to groundnut using sprinklers

Groundnut is the major oilseed crop grown in the cluster villages in an area of 65 ha under rainfed conditions with low productivity and farmers often experience crop failures due to erratic rainfall at critical stages of crop growth. This adverse effect can be overcome by providing supplemental irrigation using

Mulching in tomato in large scale adoption at NICRA village

Demonstration of drought tolerant groundnut variety Dharani

sprinklers. KVK, Chittoor conducted demonstrations on yield improvement in groundnut by giving supplemental irrigation using sprinklers during *kharif* 2016 and 2017.

During *kharif* 2016, the groundnut crop suffered due to two dry spells (1 to 29 August: 29 days and 30 August to 30 September: 32 days) during cropping season. During *kharif* 2017 also, the groundnut crop faced two dry spells (25 June to 10 July: 15 days and 17 July to 30 July: 15 days) at vegetative phase of the cropping period. KVK supplied sprinklers to farmers through Custom Hiring Center to provide supplemental irrigation to groundnut crop to overcome drought situation. About 38% increase in yield was observed in groundnut with supplementary irrigation using sprinklers (2,140 kg/ha).

Drought tolerant 'Dharani' groundnut variety

RASS KVK conducted 40 demonstrations on improved, drought and bud necrosis tolerant Dharani groundnut variety from *kharif* 2015 to 2018. Yield potential of Dharani variety is 16-26 q/ha (*Kharif*-rainfed), with 75-77% shelling outturn and 50% oil content. Hundred seed weight is 40-43 g and it is of 100-105 days duration. The variety is drought tolerant (withstands up to 35 days dry spell), uniform in maturity, high SMK (Sound Mature Kernel-90%) and has attractive pods.

Dharani groundnut variety performed better and about 15.8% increase in yield (1,796 kg/ha) was recorded over Kadiri-6 (1,551 kg/ha). It was due to more number of pods, uniform pod maturity and high shelling percentage and drought resistance during dry spells, tolerance to bud necrosis . The technology disseminated to an area of around 1,000 ha in the mandal and nearby mandals.

Triple disease resistant tomato hybrid, Arka Samrat

Traditionally farmers in NICRA cluster villages cultivate private hybrids in tomato crop which are susceptible to diseases like tomato leaf curl virus, bacterial wilt and early blight causing considerable yield loss. Farmers are used to managing diseases by spraying combination of fungicides 8-10 times during cropping period by spending huge amount. Hence RASS KVK demonstrated triple disease resistant tomato hybrid, Arka Smarat during the years 2017-18 and 2018-19. It is resistant to tomato leaf curl, bacterial wilt and early blight with a yield potential of 80-85 t/ha in 140 days. Arka Samrat recorded about 11.6% increase in yield (58,520 kg/ha) when compared to Sweekar 448 (52,200 kg/ha). Cost of tomato production was more in Sweekar 448 due to more amount (₹6,000 per ha) incurred by the farmers for disease control. Disease incidence was not observed in Arka Samrat, whereas about 1-25% incidence was observed in Sweekar 448.

Resource conservation technology in paddy – Direct seeding using drum seeder

Manual transplanting is the most common method of crop establishment in paddy in the cluster villages. It involves nursery bed preparation, nursery growing, care of seedlings, uprooting of seedlings and transport to main field. All these operations requires more number of labour and hence increases the cost of cultivation and also often results in delay in transplanting because of shortage of labour. Increasing water scarcity is also becoming real threat for paddy cultivation. Direct seeding using drum seeder avoids raising of nursery, pulling of seedlings and transportation of the same to main field so that labour requirement for crop establishment is negligible. This method also requires less water as it avoids nursery and reduces crop duration. RASS KVK conducted demonstrations in NICRA cluster villages on direct seeding in rice using drum seeder during 2015 to 2018 during *rabi* season using the variety RNR-15048, which is a fine grain variety of 125 days duration and blast tolerant.

Demonstration of Arka Samrat tomato hybrid.

On an average, direct seeded paddy using drum seeder recorded 11.5% higher grain yield (6,442 kg/ha), 18.4% low cost of cultivation (₹47,586 per ha) and 64% higher net returns (₹50,817 per ha) as compared to manual transplanting method. Majority of the farmers in the district are practicing this technology as it overcomes labour shortage, reduces cost of cultivation, water requirement in addition to yield enhancement.

SUMMARY

The implementation of climate resilient technologies played a key role in transforming climate vulnerable agriculture to climate smart agriculture in drought prone villages of erstwhile Chittoor district in Andhra Pradesh. An integrated participatory approach through natural resource management, productivity enhancement in crops paid dividends in transforming this drought prone village into a climate resilient village.

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Sustainable livelihood security through apiculture

in the tribal tracts of West Godavari district of Andhra Pradesh

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*In the mono-cropped tribal dominant villages of West Godavari district in Andhra Pradesh, collection of honey from wild bee colonies has been a major source of income during the non-cropped rabi season. This skill of collecting honey has been on a decline among the tribal youth over years. In order to ensure sustained livelihood security to tribal farmers during the lean months of the year, an ICAR project under Tribal Sub Plan (TSP) was launched by the Krishi Vigyan Kendra (KVK), West Godavari (V R Gudem) covering 11 villages in 2 tribal mandals viz. Velerupadu and Buttaigudem in convergence with ITDA and an NGO Raithu Nestam. The villages were selected mainly based on the abundant forage availability. Three skill training programmes on all aspects of bee keeping were organized by the KVK and the trainees were provided with Italian bee (*Apis mellifera*) bee hive boxes (2 each), Indian bee (*Apis cerana indica*) bee hive box (1 each), comb foundation sheets and 4 honey extractors per cluster. Regular monitoring visits were made to handhold the tribal youth and to clear doubts if any on hive maintenance. In collaboration with ITDA, K R Puram, 9 cluster groups were formed and together these clusters were registered as Giridhara Honey Producers Society for production, marketing of honey and strengthening of bee keeping. This successful intervention in tribal areas ensured an average additional earning of ₹19,000 per year to each tribal family. This success has triggered enthusiasm among tribal youth who have been expanding the activity by the division of the bee colonies. Support in the form of regular training, handholding for maintenance of colonies, value addition and provision of market linkages in the future will strengthen this entrepreneurial activity and ensure sustained livelihood security to the resource poor tribal youth of West Godavari district.*

Keywords: Apiary, Livelihood security, Tribal sub plan, West Godavari

THE coastal district of West Godavari in Andhra Pradesh has 2.8% of total population (Census 2011). The two mandals of the district, viz. Buttaiahgudem and Velerpadu have villages with predominance of tribal population to an extent of 90-100%. Majority of the tribal farmers are small and marginal and they do mono-cropping of paddy, cotton or pulses on their red sandy loam soils. Cashew is the predominant horticultural crop in these tribal tracts. Their average income ranges between ₹28000-36000 per acre per annum. Small landholding size and traditional technology are no longer able to meet the rising demands of this tribal population. Forest resources are also very rapidly declining due to huge industrial demands and ever-increasing household needs. The collection of honey from wild bee colonies which has been one of the income sources for tribal families during lean periods of agriculture i.e., during November to March is slowly declining as the skill of identifying the wild bee colonies and honey extraction is not inherited by tribal young farmers. Moreover, fire and smoke that are used to rid the bees from their nests for collecting honey from wild can destroy the entire colony and can also ignite wild fires. The honey and wax obtained from such a practice are of low quality. In this context, Krishi Vigyan Kendra (KVK), West Godavari under Dr YSR Horticultural University-initiated activities for promoting apiary among tribal youth as it is a cost effective, eco-friendly and gender friendly enterprise that requires minimum land ownership to operate and has the potential to

alleviate the socio-economic conditions of the people via full time or part time engagement besides providing ecological services like pollination. Bees provide a plethora of products (honey, wax, pollen, royal jelly, propolis, venom, etc.) that a small-scale farmer can sell from a single farm enterprise. These products can also, with minimal processing, be 'transformed' into value added products.

Interventions by the KVK, West Godavari to promote apiary in tribal villages

Under the ICAR-Tribal Sub Plan (TSP) project entitled 'Introduction of apiary in tribal villages for enhanced income and economic security', preliminary visits were conducted by KVK staff in collaboration with ITDA, K R Puram and Rythu Nestham, an NGO in tribal mandals to select suitable sites for honeybee foraging. The project was successfully implemented in two tribal mandals viz. Velerupadu and Buttaigudem. A total of 3 villages were covered in Velerupadu mandal (Katkuru, Koida and Kacharam) whereas 8 villages were covered in Buttaigudem mandal (Aliveru, Chinnajeedipudi, Yerraigudem, Pandugudem, Bandarlagudem, Kamaiahkunta, Lankapalli and palakunta). The villages were selected mainly due to abundant forage availability like tamarind, neem, soapnut, eucalyptus, pongamia, tobacco, cashew and palmyrah etc. A total of 100 tribal youth were selected and three 6 day long trainings were conducted. During the training, aspects like types of bees, classification, bee hive structure and management, life cycle of various categories of bees, parts of bee hive box, accessories required for honey been keeping and honey extraction were covered. After successful completion of these vocational training programmes, the trainees were provided with the following critical inputs:

- Italian bee *(Apis mellifera)* beehive boxes – 2, Indian bee *(Apis cerana indica)* beehive box– 1 and Comb foundation sheets – ½ kg for each trainee.
- Honey extractors (*A. mellifera* – 2 and *A. cerana* - 2) per cluster.

Regular follow up visits were also conducted by the scientists of KVK to the apiary units and advice was also provided for effective maintenance of the bee hive boxes. The following is the summary of various interventions undertaken by the KVK to promote apiary in the tribal villages of West Godavari.

- A total of 15 trainings were conducted under RKVY and ICAR – TSP and 350 farmers and rural youth including women were imparted with beekeeping training from 2015-16 to 2019-20.
- During 2015-16 KVK-Venkataramannagudem initiated apiary unit consisting of 13 *Apis mellifera* bee hive boxes and one honey extractor with the financial assistance of '*Rashtriya Krishi Vikas Yojana*' for training and demonstration purposes.
- A long (25 days) skill training on beekeeping conducted under ASCI during 2018-19.
- One State level seminar on 'Awareness, motivation and technology transfer for development of beekeeping in Andhra Pradesh' was organized.
- Three physical trainings and one virtual training were conducted during 2020-21 and 2021- 22 with funding by National Bee Board (NBB) for the promotion of scientific bee keeping.
- Fifty apiary units were established through training and provision of critical inputs of apiary under the ICAR funded project 'Attracting and Retaining Youth in Agriculture (ARYA)'.
- Integrated Bee Keeping Development Center (IBDC) / Center of excellence in bee keeping was established in the KVK with financial support of ₹87.96 lakhs by National Bee Board (NBB). As a part of this project, honey quality control lab, disease diagnostic lab, manufacturing unit of beehives, beekeeping equipment and tools, information Centre and honey processing and marketing centre were established.

Impact of the training programme and handholding

Tribal youth and women gained hands on experience on bee keeping through the trainings,

Success story of an apiary entrepreneur

Name of the farmer: Akkina Satya Chaitanya – Sowjanya bee honey

Technological intervention

Under the ICAR-ARYA project, KVK (V R Gudem) imparted training programme on scientific beekeeping and supplied *A. mellifera* bee hive boxes (4 nos.)

Output of the intervention

- 700 bee boxes are maintained which yield, 4 tonnes of honey per month
- Established 11 outlets in villages viz., Venkataramannagudem, Narayanapuram, Tadepalligduem, Eluru, Dwarka, Tirumula, Akivedu, Bhimavaram, Tanuku, Dubcherla and Ravulapalem.
- Retail honey is sold locally @ ₹350 per Kg
- Bee colonies with box are sold @ ₹4500 per unit
- The farmer is earning a net income of ₹12,00,000 per year

Future plan of action: To increase his bee colonies to 2000 and to establish some more outlets to cater to consumers.

demonstrations and exposure visits organized by the KVK, West Godavari (V R Gudem). The apiary-based entrepreneurship activity ensured an average additional net income of additional income @ ₹19,000 per year to each tribal family. The existing apiary units can be further scaled up through the division of bee colonies and the success thus has come to stay. Support in terms of feeding, protection from ants and termites as well as making availability of comb foundation sheets are to be provided to these beekeepers for strengthening the activity. The apiary unit established at the KVK was strengthened from 13 bee hive colonies to 120 and honey (on an average 700 kg per month) and bee colonies are sold to farmers and aspiring bee farmers. KVK, Venkataramannagudem in collaboration with ITDA, K R Puram formed 9 individual cluster groups of bee keepers covering 11 villages and these individual cluster groups in turn formed an association of honey producers with the name *'Giridhara Honey Producers Society'* in ITDA, K R Puram for production, marketing of honey and strengthening of bee keeping. Branding of the product and FSSAI registration has been completed. Beekeeping was proven to be an alternative livelihood option with potential of providing alternative income security to smallholder tribal farmers living in forest area of Dantewada district of Chattisgarh. Of the 500 beneficiaries of 16 villages who were taken as a unit for analysis to check the enhancement of farmer's income annually, 470 beneficiaries were found highly benefitted by bee keeping which brought tangible change in their living standards. In a study by the scientist of the KVK (West Godavari), it was observed that age, education, social participation, economic orientation, market orientation, extension participation and knowledge level were positively and significantly associated with extent of adoption of apiary technology for income generation.

SUMMARY

Apiary has been established through training and demonstration as a viable and sustainable source of income to tribal farmers of west Godavari district of Andhra Pradesh. The KVK, West Godavari ensured the success of this entrepreneurial activity through continued hand holding, timely advisory and establishment of market channels. Skills related to multiplication of bee colonies, preparation of bee boxes, extraction and packing of byproducts like propolis, bee wax, royal jelly would further strengthen and diversify the apiary enterprise. There is an ample scope for encouraging production of organic honey in interior tribal areas where there is minimal use of chemical inputs in agriculture and horticulture.

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Contributions of KVKs at National Level

- **Ushering pulses revolution through cluster frontline demonstration (CFLD)** - Pulses production enhanced from 17.70 MT (three years average during 2013-2016) to 27.80 MT in 2022-23.
- **Doubling farmers income through farm-based interventions** - Documentation and analysis of 75000 cases.
- **District agriculture contingency plans for 623 districts** - Ready reckoner for line departments and farming community to manage various weather aberrations.
- **Crop residue management (CRM) in 60 districts of 4 states** - Reduction (52%) in crop residue burning incidents (2021) as compared to base year 2016.
- **Scaling of IFS models - 64 IFS models for 26 States/Uts:** Thirty one bankable IFS for 22 States - 39% increase in net income of households and dietary diversity score improved by 8.57%.

New interventions to reach the unreached

Scheme	Achievement
Farmer FIRST: Farm, Innovations, Resource, Science and Technology	**20 states, 51 centres, 114 villages, 48921 farm families**
ARYA (Attracting and Retaining Youth in Agriculture)	**100 KVK, 65661 youths trained, 14878 enterprises established**
KSHAMTA (Knowledge Systems and Homestead Agriculture Management in Tribal Areas)	**26800 demonstrations. 125 tribal districts, 2 lakhs tribal farmers trained**
VATICA (Value Addition and Technology Incubation Centers in Agriculture)	**25 KVKs promoting value addition and technology incubation**
NARI (Nutri-sensitive Agricultural Resources and Innovations)	**Family farming, nutri-thali, establishment of nutri-smart villages, gender empowerment for health and nutrition**

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Seed production of pearlspot (*Etroplus suratensis*)

The State Fish of Kerala

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Pearlspot (Etroplus suratensis)*, known as Karimeen, holds cultural and culinary significance in Kerala and is designated the 'State Fish of Kerala'. With an annual demand of 10,000 MT for 'Kerala Karimeen' far exceeding the production of 2,000 MT, there is a growing interest in pearlspot culture. However, limited availability of seeds, with an annual requirement of 40 million, poses a critical challenge. Addressing the low fecundity and unique reproductive behaviours of pearlspot, this article introduces an innovative seed production approach in pond systems. The article emphasizes pond preparation for optimal conditions, brood fish management, facilitating breeding environments, breeding behaviours etc. are explored. Parental care, predator control, economic and marketing aspects are also discussed. The innovative pond system approach emerges as a promising solution for making quality seeds available for pearlspot aquaculture.*

Keywords: Breeding, Fecundity, Pearlspot, Pond systems, Seed production, Water quality

THE Pearlspot (Karimeen), native to the coastal waters of Peninsular India and colloquially known as Karimeen, stands as an iconic symbol of Kerala's culinary excellence. Renowned for its exquisite taste, it carries cultural significance in local celebrations and is a culinary highlight for tourists along Kerala's coastal line. Acknowledging the socio-economic importance, especially in backwater tourism, the Kerala government designated pearlspot as the 'State Fish of Kerala'. The inherent quality of pearlspot is intricately linked to Kerala's backwaters, imparting an authentic flavour. Locally sourced pearlspot is preferred over imports from neighbouring states, where the fish is reared in freshwater and often considered inferior.

Nevertheless, the current annual production of 2,000 MT falls drastically short of meeting the escalating demand of 10,000 MT per annum for 'Kerala Karimeen'. This substantial gap between supply and demand has prompted farmers to explore pearlspot culture. However, a critical constraint in this endeavour is the low availability of seeds. The annual seed requirement stands at 40 million, and the existing availability of only 8 million in Kerala highlights the pressing need to enhance pearlspot seed production.

Low fecundity

The primary challenge arises from the low fecundity of the species. The intricacies of pearlspot reproduction, characterized by monogamous behaviour and parental care, pose formidable obstacles to achieving large-scale seed production. The meticulous egg-laying and guarding behaviours, combined with the species' low fecundity, present significant challenges for traditional hatchery methods, rendering them economically unviable. One of the primary challenges in pearlspot seed production lies in its low fecundity when compared to species like Carp fish. The prolonged nursery-rearing period and the distinctive parental care behaviour exhibited by pearlspot further compound the difficulties in large-scale seed production. These factors set it apart from other fish species, presenting unique hurdles that demand innovative solutions for sustainable aquaculture. Addressing these challenges is crucial for meeting the increasing demand for pearlspot and enhancing its commercial viability in the market. In addressing these challenges, ICAR-KVK, Ernakulam has undertaken an initiative to significantly enhance seed production by utilizing pond systems instead of the commonly followed hatchery method. This innovative approach presents a promising solution to bridge the existing demand-supply gap.

Seed production in natural ponds

Producing seeds in pond systems incur significantly lower investments and operational expenses when compared to hatchery systems. However, the yield in pond systems tends to be substantially lower due to challenges such as water quality issues and attacks by predators. Natural pond conditions significantly influence successful egg production, emphasizing the importance of well-prepared ponds.

Pond preparation involves several steps, including de-watering, removal of excess humus, and eradication of weed fish using tea seed cake (at the rate of 5 g per m^2 pond area). Subsequently, the pond bottom needs to be sun-dried. Afterwards, powdered dolomite is applied (at the rate of 100 g per m^2 pond area) as a liming material to correct acidity and enhance phosphorus and carbon content, promoting higher phytoplankton production. Following this, the ponds are filled with water using a pump through a 200-micron mesh screen to prevent the entry of unwanted fish or fish eggs. Pond fertilization involves the application of dried cow dung (4 kg/cent), groundnut cake (300 g/cent), and urea (50 g/cent). To induce consistent production of phytoplankton bloom in ponds, it is essential to apply fermented liquid extract of oil Sardine and Jaggery at the rate of 1 ml/m^2 of pond area an at interval of 15 days.

Creating breeding environment

In one acre pond, 400 sufficiently mature pearlspot brood fish each approximately weighing 100-150 g and 100-200 mm length need to be deposited. Ensuring proper nutrition, a formulated feed with 40% protein and 8% fat in the form of 3 mm floating pellets is advised. The feeding regimen should be carried out during both dawn and dusk to meet the dietary needs of the brood fish. This strategic approach aims to enhance the health and reproductive capabilities of the pearlspot brood fish, contributing to a thriving aquaculture environment in the one-acre pond.

Pearlspot brooders show a preference for stationary solid objects for egg-laying, particularly those near the bunds. Therefore, the installation of mud tiles, each approximately 400 mm in length and 150 mm in width, and wooden poles measuring 1 m in length, made of materials such as bamboo and casuarina, is recommended. These structures should be erected vertically on the pond bottom in a line, maintaining a constant distance of 1 m from the sidewalls of the ponds. It is advisable to keep a pole-to-pole distance of 2 m to facilitate brooders in affixing their eggs.

Breeding and egg hatching

Pearlspots exhibit year-round breeding tendencies, with peak breeding periods observed from February to May and October to December. The pearlspot brood fishes move in pairs around the sides of the ponds approximately seven days after stocking. The brood fish's kissing behaviour and jumping movements around the bamboo poles are indications of egg-laying. Together, the pair clean the bamboo substrate using their mouths and subsequently lay eggs.

Eggs undergo a continuous colour transformation as they advance towards hatching stage. Soon after fertilization, the egg's colour will be yellow, which changes to brown, dark brown, and eventually black. Approximately 90-96 hours of incubation is necessary for the eggs to hatch. From a single batch of eggs, an average of 900 to 950 fries can hatch out, resulting in an average hatching percentage of approximately 80-85. For the first two days, no external feed is necessary for the fries, which are around 800±40 µm in size, due to the presence of a sufficient yolk sac. After the yolk sac is reabsorbed, the fries, now measuring 1500±90 µm, begin to rise to the surface for active feeding. To ensure the robust growth of pearlspot fish fry, a consistent feeding regimen is crucial. Employing a specially formulated dust feed with 40% protein and 10% fat at both dawn and dusk proves to be an effective strategy. Feeding in close proximity to dip nets plays a crucial role in conditioning the fry, encouraging them to gather near the nets. This conditioning significantly enhances the efficiency of harvesting, ensuring a seamless harvesting whenever required.

Parental care

The brood fishes create small pits in the pond bottom to provide a secure space for the tiny hatchlings, shielding them from potential predators. These brood fishes exhibit parental care by relocating the seeds from one pit to another at different intervals, demonstrating a protective behaviour. This involves keeping the fry in small pits near the egg colonies on the pond bottom for 4 to 5 days. The early separation of pearlspot fry from their parents facilitates subsequent spawning at an earlier stage.The school of fish fries adopts a spherical shape while moving during the first month after hatching, possibly as a natural defensive mechanism to deter predatory fishes. The transition from the fry stage to reaching a marketable size seed can take approximately 2 months.

Predator control

The presence of predatory weed fishes, such as *Etroplus maculatus*, frequently diminishes the seed survival percentage. Despite attempts to eradicate these weed fishes during pond preparation, certain eggs or larvae persist, grow in the ponds, and subsequently function as predators. In the event of a surge in the population of weed fishes within the breeding ponds, their elimination may need to be carried out twice a year by resetting the pond and repeating all the pond preparation procedures. As birds prey on fish larvae and fry on a massive scale in breeding ponds, the top surface of the ponds needs to be covered with 1.25 mm thick

and 60 mm mesh high-density polyethylene (HDPE) nets. Similarly, the pond-side walls are covered with 2.5 mm wide and 30 mm mesh HDPE nets to prevent otters' entry.

Pest control and water quality

The existence of the ectoparasite *Caligus minimus* poses a substantial threat to pearlspot seed production. To mitigate this risk, it is crucial to uphold optimal water quality. Additionally, careful broodstock selection is essential to ensure that the brood fish introduced to the ponds are free from external parasites. Achieving this involves stocking the brood fish in separate tanks or ponds for quarantine, typically for about a week, to meticulously confirm the absence of external parasites. This quarantine process stands as the most effective measure to prevent the entry of external parasites into the ponds.

A precautionary approach to water quality management is essential for preventing and controlling infestations in breeding ponds. Achieving optimal pond water quality involves the systematic use of probiotics to ensure the decomposition of fish faecal matter and other wastes accumulated at the pond's bottom. Regular applications of probiotics enhance water quality, creating a favourable environment for phytoplankton bloom. This proactive approach not only supports the overall health of the aquatic ecosystem but also plays a pivotal role in sustaining a thriving pearlspot population.

In some instances, even with probiotics, water quality may not improve. Water exchange can be practiced in such cases, but precautions should be taken to prevent the entry of weed fishes into the ponds. Occasionally, water exchange may not be possible due to poor water quality in the external water source. In such situations, installing an air-giving mechanism is advisable, especially in nursery-rearing happa units.

Overfeeding can contribute to water quality problems, making it advisable to adopt an on-demand feeding approach to minimize feed wastage. Feed wastage, if left unattended, has the potential to contaminate the water. In certain instances, an excessive proliferation of algae may occur. In such cases, prompt water exchange is recommended, coupled with the removal of slurry from the ponds to prevent oxygen depletion and mitigate the risk of sudden fish mortality.

Harvesting, packing and transportation

Dip nets of 4 m × 4 m size erected at four corners of the ponds help with periodic seed collection. Seed collection can commence two months after stocking. Approximately 40,000 to 60,000 seeds can be harvested from a 1-acre pond within a year, with variations depending on factors such as water quality, soil type, harvesting methods, pond management, etc. The initial step following seed collection is maintaining them in a healthy condition in ponds or tanks before marketing. Extreme care is essential during this phase to ensure the health of the fish seed. Provide ample aeration to the happa nets or tanks before packing.

Cease larval feeding 24 hr prior to packing, and transportation measures are necessary to minimize stress during transit. Packing should be carried out using polythene bags with ideal dimensions of 36 inches in height and 12 inches in width, possessing a thickness of 300 microns. It is crucial to arrange medical oxygen cylinders for filling the bags to create a healthier environment for the fish. Typically, in regular circumstances, 50 fingerling-size seeds can be stocked in a bag, packed, and kept viable for up to 8 hours. If the travel duration exceeds this, reduce the number of fish in the packet. Transport activities should be scheduled for early morning or evening, and the use of air-conditioned vehicles is imperative to prevent heat stress.

Economics and marketing

The production cost for a single fingerling in a pond system amounts to ₹3.5. Consequently, the seed should be marketed at a minimum price of ₹ 7.0 per seed and the overall cost-benefit ratio stands at 2.15. For optimal survival at the farmers' end, the minimum size for saleable seeds should exceed 5 cm.

It is imperative to disseminate information regarding the availability of these seeds to other farmers through channels such as newspapers, brochures, posters, and social media, leveraging the power of free advertisements within the farming community. Additionally, on-site delivery services can be extended if farmers acquire at least 2,000 seeds or more, particularly within the same district. Agriculture magazines can serve as effective platforms for promoting this news, and farmers are encouraged to explore innovative methods for marketing their produce at a premium price, bypassing intermediaries. The successful buy-back arrangements and marketing models demonstrated by ICAR-KVK Ernakulam in the Ernakulam region are viable examples supporting agencies can adopt.

SUMMARY

The innovative pond system approach for pearlspot seed production, introduced by ICAR-KVK, Ernakulam, emerges as a promising solution to bridge the gap between demand and supply. Overcoming challenges like low fecundity and intricate breeding behaviours, this method offers a cost-effective alternative to traditional hatchery systems. The emphasis on water quality management, predator control, and efficient harvesting techniques contributes to the success of sustainable pearlspot aquaculture. The economic feasibility and marketing strategies presented provide valuable insights for farmers, ensuring optimal seed production and dissemination in the market.

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Eco-friendly management

of pests and diseases in small cardamom

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Small cardamom, known as 'green gold', symbolizes India's prominence in the global spice market, originating from the Western Ghats Forest in southern India. Over time, environmental changes in this region have led to indiscriminate use of synthetic chemical pesticides by farmers, resulting in environmental degradation and high pesticide residue levels in produce. As focus shifts towards organic small cardamom production, the search for safer pest and disease management measures becomes crucial. ICAR-National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru, has developed various bio-agents effective for eco-friendly management of major cardamom pests and diseases. In the last five years, ICAR-KVK, Idukki, has extensively disseminated these technologies among small cardamom farmers through various activities, leading to increased adoption of eco-friendly practices, reduced pesticide usage, improved crop health, and sustainable production. With a growing demand for organic spices, ICAR-NBAIR technologies have played a pivotal role in Idukki district, enabling the production and export of safer small cardamom and its value-added products to domestic and international markets.

Keywords: Bio-agents, Diseases, ICAR-NBAIR, ICAR-KVK, Insect pests, Small cardamom

SMALL cardamom, one of the most valued spice crops, popularly known as green gold, is a native of the evergreen rainforests of Western Ghats. Cardamom hills comprised the mountain range of southern India and southern Western Ghats are the hotspot area for cardamom cultivation. Out of three cardamom producing states (Kerala, Tamil Nadu and Karnataka), Kerala accounts for 88% of total production in India. Cardamom hill reserves within the cardamom hills of Idukki district, Kerala, comprises about 7488.40 ha of land and accounts for about 70% of the cardamom production of India. The perennial and succulent nature of the crop provides agreeable conditions for the pathogens to proliferate and perpetuate throughout the year. Also, the humid environment coupled with the partial shade under which the crop is grown creates a very suitable condition for the multiplication of the plant pathogens. This situation is challenging for the profitable cultivation of cardamom in Cardamom hill reserves of Kerala. The major pests of small cardamom are shoot and capsule borer, thrips, root grub, whitefly, nematodes and diseases like capsule and panicle rot, clump rot, Fusarium rot, leaf blight and viral diseases are reported as major threats to commercial cardamom cultivation. Indiscriminate use of synthetic pesticides to manage these pests and diseases results in tremendous buildup of residues in export-oriented produce, which has recently invited debate and queries. This had significantly affected the world-wide acceptability of the king and queen of spices. Now, the demand for organic spices is increasing among consumers at the rate of 20% annually. The mission at the moment is to capture India's pre-eminent position as spice bowl of the world by producing and exporting safer spices and spice products to the world market. For safer and continuous higher sustainable production, attention is needed on good agricultural practices through eco-friendly management of pests and diseases. If India has to recapture its lost glory of spices, there should be considerable sincere efforts to achieve a quantum jump

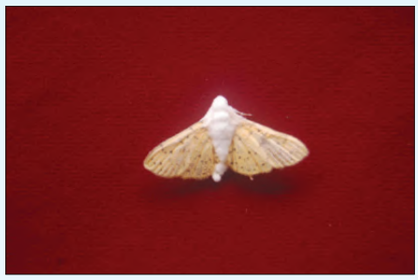
Bore hole symptoms on stem and pupa

Adult borer

Dead heart symptoms on shoot

Bore hole symptoms on capsules

Apantele sp parasitoids on capsule borer



Beauveria infected adult

in the productivity of cardamom through adoption of physical, cultural and biological/botanical practices that allow co-existence of natural enemies and beneficial microorganisms which in turn bring back the ecosystem balance in small cardamom production system.

In this direction, ICAR-KVK, Idukki has disseminated eco-friendly technologies developed by ICAR-NBAIR, Bengaluru for the management of major pests and diseases of small cardamom through various activities like OFTs, FLDs, trainings, extension programmes and farm advisory services. Over the years, the salient achievements of ICAR-KVK, Idukki for the management of pests and diseases of cardamom by application of ICAR-NBAIR technologies, apart from recommended physical and cultural practices, are described hereunder.

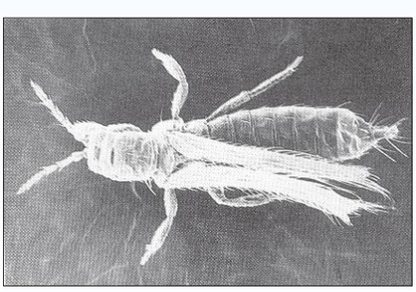
Insect pests of small cardamom

Shoot and capsule borer (*Dichocrocis punctiferalis*): It is the most serious insect pest of cardamom and consumes major share of pesticide used in cardamom. The earlier stages of larvae bore the panicles leading to drying up of the entire panicle and also bore the immature capsules and feed on the inner contents of the seeds which lead to empty capsules. The late stages larva feed on the central core of the stem and affect the phloem vessels interrupting the passage of food materials to the growing parts finally leading to drying of central leaf tip known as 'dead heart' symptom.

This pest was addressed through spraying of ICAR-NBAIR-*Bacillus thuringiensis* @ 5 ml/L of water at First - instar larvae stage, spraying of ICAR-NBAIR-*Beauveria bassiana* @ 5 g/L of water at 3rd and 4th instar larvae and adult stage, releasing of *Apantele sp*. @ 20,000 larval parasites/ha at 2nd and 3rd instar larvae and releasing of *Friona sp* @ 20,000 larval parasites/ha. As a result, the number of farmers who adopted this technology has increased and the number of chemical pesticides in use has decreased from 14 to 6%, thereby paving the way for a healthy and resilient farming system.

Thrips (*Sciothrips cardamomi*): This is one of the most destructive insect pests of cardamom. The population of this pest builds up rapidly during the post monsoon and summer months and declines with the onset of monsoon rains.

This pest was addressed through spraying of ICAR-NBAIR strain of entomopathogenic fungus *Lecanicillium lecani* and release of ICAR-NBAIR-Anthocorid bug and *Chrysoperla* sp. It played a significant role in acreage expansion as well as yield enhancement. It was found that the realized yield levels through demonstrations were much higher (15.0%) than the average district yield (6.40 t/ha). The total area of bio-intensive pest management of thrips in small cardamom expanded from 100 to 500 ha.



Microscopic view of adult thrips

Thrips on under leaf sheath

Green cardamom capsule damaged by thrips

Corky encrustations on pods

Lecanicillium applied green capsules

Lecanicillium applied dry capsules

Root grub: The root grub (*Basilepta fulvicorne*) is one of the serious subterranean insect pests in cardamom plantations. The larvae feed on young roots and the above ground symptoms start as yellowing of leaves, which later result in the drying up and death of the plant.

This pest was addressed through soil application of Entamopathogenic Nematode (EPN) power formulation @ 5 g per L of water in soil at the base of small cardamom plant (@5 L of EPN liquid per plant which mean two lakh to four lakh IJs of EPN). The IJs of EPN comes out from the cadaver in the soil, search for root grub and kill them. Field demonstrations of the formulation were carried out in Kerala and around 13,000 ha small cardamom fields were applied with WP formulations of *H. indica* @ 4-5 kg/acre respectively. The technology could reduce the small cardamom root grub incidence by 62-78%. ICAR-KVK, Idukki has distributed more than 11,000 kg of WP EPN formulation to the farmers for the management of root grubs in small cardamom.

Root grubs

EPN infected root grubs

Demonstration field of EPN

EPN applied small cardamom plantation

Nematode: Infestation of nematode in cardamom is a major problem often amounting to heavy crop loss. The root-knot nematode, *Meloidogyne incognita*, causes severe damage to crop that is widely observed in almost all cardamom plantations, while the lesion nematode *Pratylenchus coffeae* and the burrowing nematode *Radopholus similis* are noticed in mixed plantations. Infested plants exhibit stunting, reduced tillering, reduced leaf size, yellowing of foliage, immature capsule drop and increased incidence of rhizome rot.

This pest was addressed through soil application of *Paecilomyces lilacinus* strain ICAR-NBAII Plft5 (Pl55) @ 1 kg in 50 kg FYM in small cardamom and soil application of Jeevamrutha @ 10 litre along with *Azospirillum* and ICAR-NBAIR-*Trichoderma viride* (10 g each) per plant in cardamom plantations. Before the adoption of ICAR-NBAIR technology, only chemical methods were followed and incidence of root knot nematode was 57.2% and net return ₹1,72,900/ha. After adoption of ICAR-NBAIR technology, the incidence of root knot nematode was only 6.5% and yield increased by 41% with net returns of ₹4,22,000/ ha.

Root knot nematode affected roots

Root knot nematode affected plants

Root knot nematode managed through ICAR-NBAIR bio-agents

Diseases of small cardamom

Capsule rot/Panicle rot: This disease popularly known as azhukal which is most serious disease in cardamom. Studies on etiology of the disease confirmed that two species of *Phytophthora,* viz. *P. meadii* and *P. nicotianae* var. *nicotianae* are involved in this disease. Disease symptoms appear during the rainy season on leaves, tender shoots, panicles and capsules. On the infected leaves, water soaked lesions appear first and rotting and shredding of leaves along the veins occur thereafter. The infected capsules become dull greenish brown and rot. This emits a foul smell and subsequently shed off. Infection spreads to panicles and tillers resulting a complete decay of panicles and capsules.

This disease was addressed through application of peat formulation of ICAR-NBAIR-*Bacilus subtilis* strain Bs and prophylactic application of ICAR-NBAIR-*Pseudomonas fluorescens* (2% spray) along with

Leaf water soaked lesions and rotting

Capsules dull greenish brown and rot

basal application of *Glomus fasciculatum* (arbuscular mycorrhizal fungi AMF) @ 50 g and ICAR-NBAIR-*Trichoderma viride* @ 100 g/plant at a monthly interval during the rainy season. The cost of application of ICAR-NBAIR-*Bacilus subtilis* is ₹4,400/ha as compared to regular chemical application where it costs ₹18,900/ha. Thus, it saves the cost of chemical application at the rate of ₹14,500 per ha and net returns gained per ha is ₹2,79,000.

Capsule rot/Panicle rot disease managed through ICAR-NBAIR bio-agents

Clump rot: It is otherwise called as rhizome rot occurs during monsoon period. This disease is widely distributed across cardamom growing regions in Kerala and Karnataka as well as heavy rainfall areas of Tamil Nadu such as the Anamalai hills. This disease is caused by combined infection of *Pythium vexans*, *Rhizoctonia solani* and *Fusarium* sp. Rotting symptoms develop at the collar region resulting in softening and bristling of the tissue. The tiller breaks at this point with a discolouration, and the infected tissue in the detached portion emits a foul smell. The developing tillers of the infected plants detach from their rhizome portion with a slight pull. Generally, root rotting and subsequent yellowing of plants are associated with the disease.

Rotting at the collar region in softening and bristling of the tissue

This disease was addressed through soil application by a consortium of ICAR-NBAIR-*Pseudomonas fluorescens* (Pf5) and ICAR-NBAIR-*Bacillus subtilis* (Bs45) and soil application of ICAR-NBAIR-*Trichoderma harzianum* multiplied in a mixture of decomposed coffee compost and cow dung at 50g/clump during May–June and August–September. Ex-trainee of ICAR-KVK, Idukki Mr. Srinivasan from Santhanpara village in the Idukki district has been involved in the bio-control program since 2011. Approximately 5.25 ha are cultivated by him for small cardamom. When it came to crop productivity, he previously employed more chemical herbicides and fertilizers. It was via ICAR-KVK, Idukki that Mr. Srinivasan participated in a number of training programs. The vermicompost he uses, generated on his own farms, amounts to approximately 200 q annually. He started multiplying ICAR-NBAIR bio-agents and selling approximately 300 liters of various bio-agents and gaining an extra ₹4,50,000 annually.

Fusarium rot: This disease is also called as stem rot or stems lodging, normally appears during post-monsoon period. The disease was first reported in the cardamom plantations of Idukki district. This disease is caused by a fungus *Fusarium oxysporum*. The pathogen usually attacks middle portion of the tillers and produces a pale discoloured lesion leading to dry rotting. The infected tillers are weakened at the point of infection and leads to partial breakage of the tillers. The partially broken tillers bend down and hang from the point of infection. The infected tillers fall off and give lodged appearance if the infection occurs at lower part of the tillers.

Clump rot disease managed through ICAR-NBAIR bio-agents by farmer Mr. Srinivasan

Pseudo stem rot

Tillers bend down and hang

Panicle blight

Wilting symptoms

This disease was addressed through prophylactic application of 2% ICAR-NBAIR-*Pseudomonas fluorescens* (Pf5) in cowdung slurry as spray and drench or single basal application of ICAR-NBAIR-*Trichoderma harzianum* (100 g) and *Glomus fasciculatum* (50 g) per plant along with 2% ICAR-NBAIR-*Pseudomonas fluorescens* (Pf5) and ICAR-NBAIR-*Bacilus. subtilis* (Bs45) spray at monthly intervals during summer months. Ex-trainee of ICAR-KVK, Idukki, Mr. Manikandan belonging to Senapathy village in Idukki district has four acres of land and is cultivating small cardamom. Fusarium disease was affected by the disease intensity (DI) level in his farm and he attempted to suppress the disease below DI level through numerous fungicides, but remained unsuccessful. From 2016 until now, he has been connected to the KVK and adopted ICAR-NBAIR technology. As a result, he controlled the disease and saves his annual cost of cultivation of ₹1,50,000. He now harvests good produce on his farm to the extent possible.

SUMMARY

Small cardamom, one of the most valued spice crops, popularly known as green gold, is a native of the evergreen rainforests of Western Ghats. Cardamom hill reserves within the cardamom hills of Idukki district, Kerala account for 70% of the cardemon production of India. Existing climatic situation is challenging for the profitable cultivation of cardamom in Cardamom hill reserves of Kerala as it is congenial for occurrence and incidence of insect pests and diseases, which


Fusarium rot disease managed through ICAR-NBAIR bio-agents by farmer Mr. Manikandan

invites indiscriminate use of synthetic pesticides. For safer and continuous higher sustainable production, attention is needed on good agricultural practices through eco-friendly management of pests and diseases. The ICAR-NBAIR, Bengaluru has developed several bio-agents viz., *Bacillus thuringiensis, Beauveria bassiana, Apantele* sp., *Friona* sp., entomopathogenic fungus *Lecanicillium lecani*, Anthocorid bug, *chrysoperla sp*., entamopathogenic Nematode (EPN), *Paecilomyces lilacinus* Plft5 (Pl55), *Bacillus subtilis, Pseudomonas fluorescens, Glomus fasciculatum, Trichoderma viride* and *Trichoderma harzianum* are effective for eco-friendly management of major insect pests of cardamom - shoot and capsule borer, thrips, root grubs and nematode as well as major diseases of cardamom-capsule rot/panicle rot, clump rot and *Fusarium* rot. These technologies were widely disseminated among farmers by ICAR-KVK, Idukki through various activities. This has led farmers to adopt ICAR-NBAIR technologies for eco-friendly management of small cardamom thereby reduced usage of chemical pesticides, saved expenditure on plant protection, grown healthy crop, harvested quality produce and brought small cardamom production system sustainable. In fact, eco-friendly technologies and practices are low input demanding, energy efficient and cause little or minimum disturbance to the production system. As the demand for organic spices is increasing among consumers at the rate of 20% annually, ICAR-NBAIR technologies played a pivotal role in Idukki district for producing and exporting safer small cardamom and its value-added products to the domestic and world market.

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Transplanting in redgram

for resource effective crop production to unleash the potential yield

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In India, redgram or pigeonpea (Cajanus cajan) is predominantly cultivated in Uttar Pradesh, Madhya Pradesh, West Bengal, Bihar, Jharkhand, Maharashtra, Karnataka, Andhra Pradesh, Telangana, Gujarat, Odisha, Chattisgarh, and Tamil Nadu. It is one of the major pulse crops in Northern Karnataka, covering approximately 5.14 lakh ha with a production of 2.42 lakh tonnes (766 kg/ha). Bidar district, known as the pulse bowl of Karnataka, accounts for a significant share of redgram cultivation, spanning 65,642 ha. However, dry land cultivation of redgram faces various agronomic challenges and inefficient water management, leading to diminishing productivity amidst water scarcity and rainfall uncertainty. Addressing these challenges, ICAR-KVK, Bidar initiated a trial on redgram transplanting after collaborative discussions with progressive farmers and scientists in 2004-05, yielding promising results. Subsequently, ICAR-KVK, Bidar conducted various activities like on-farm trials (OFTs), frontline demonstrations (FLDs), capacity-building programs, and farm advisory services. Through FLDs, redgram transplanting technology was standardized, achieving an average seed yield of 29.70 quintals/ha and net income of ₹ 1,07,240/ha compared to traditional practices, with an average yield of 17.5 quintals/ha and net income of ₹ 58,500/ha during 2009-10 to 2014-15. Adoption of transplanting technology resulted in yield increases ranging from 69.71% to 138% compared to traditional practices. ICAR-KVK, Bidar standardized redgram transplanting technology by preparing healthy seedlings of 30-day-old and transplanting them in the field. This technology adoption led to unprecedented yields, prompting its horizontal spread to 2000 hectares in Bidar district and neighbouring districts of Karnataka, Maharashtra, Telangana, Andhra Pradesh, Odisha, Chattisgarh, and Tamil Nadu. Redgram transplanting offers several advantages including higher yields and income, and has become a resource-efficient crop production approach tailored to the specific needs of small and marginal farmers in dry land farming areas, not only in Bidar district but also across Karnataka and other states nationwide.

Keywords: Gross returns, ICAR-KVK, Net returns, Redgram, Seedlings, Transplanting, Yield

PIGEONPEA (*Cajanus cajan* L. Millsp.) popularly known as tur or arhar is one of the major pulses of the tropics and subtropics endowed with several unique characteristics. It is the most versatile legume crop with diversified uses. viz. food, feed, fodder and fuel. It is the fourth most important pulse crop in the world with almost all production confining to developing countries. It finds an important place in the farming system adopted by small farmers in many developing countries. In India, pigeonpea or redgram occupies an acreage of 5.05 million ha with a productivity of 859 kg/ha and production of 4.34 million tonnes. India contributed to 77.61% of the global pigeonpea production during 2020. In India, Uttar Pradesh is the leading producer (0.47 million tonnes from 0.49 million ha with a productivity of 944 kg/ha) contributing to 34.87% of the national production (Fourth advanced estimates, DES, MoAF&W, 2022) followed by Madhya Pradesh (0.44

million tonnes, 34.55% of national production), West Bengal (10.53%), Bihar (8.84%) and Jharkhand (4.53%).

Redgram is one of the major pulse crops of Northern Karnataka and cultivated in 5.14 lakh ha with a production of 2.42 lakh tonnes (766 kg/ha). Bidar district is considered as pulse bowl of Karnataka wherein pulses like blackgram, greengram, redgram and bengalgram are major crops comprises 2,06,717 ha. Among these pulses, the share of redgram is to the extent of 65,642 ha. Redgram is one of the most important commercial crops for dryland farmers. However, cultivation of redgram in dry land faces major agronomic constraints like traditional cultivation practices, improper sowing time, inadequate plant population, defective method of sowing, inadequate intercultural operations, inadequate use of phosphatic fertilizers and improper method of application, apart from water scarcity, uncertainty of rainfall leading to low productivity.

Efforts of ICAR-KVK, Bidar

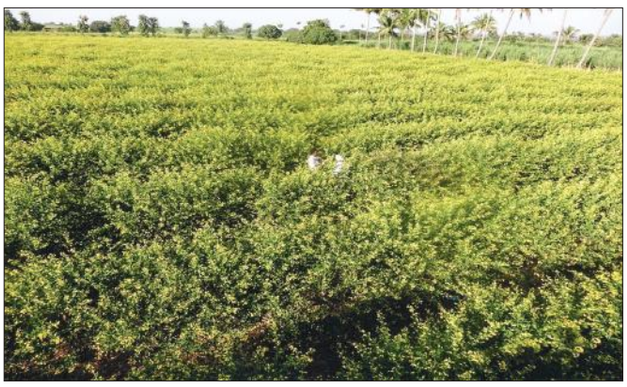
In an effort to narrow the yield gap, ICAR Krishi Vigyan Kendra, Bidar orchestrated a dynamic convergence between farmers and scientists. This innovative farmers-scientists interface delved into diverse facets aimed at elevating the yield levels of redgram. Amidst the collaborative discussions, progressive farmers and ICAR-KVK scientists forged a collective brainstorming session, ultimately giving rise to groundbreaking notions centered around transplanting and dibbling technology. This symbiotic exchange of insights could possibly transform redgram cultivation, promising a surge in productivity and the fortification of agricultural practices in the region. To assess this

Redgram seedlings

Redgram seedlings in main field

Field visit to redgram transplanting demo plot

Redgram transplanting demo plot



Aerial view of redgram transplanting demo plot

idea, the scientists of ICAR-KVK designed trials about transplanting technology. ICAR-KVK, Bidar laid out a feeler trial during 2004-05 for studying the transplanting method for 50 plants and obtained good results. With this background, during 2005-06, 2006-07 and 2007-08, an on farm testing (OFT) on redgram transplanting was conducted in 22 farmers field which was compared with dibbling and normal sowing method and able to harvest a record yield of 48.75 q per ha.

To demonstrate on larger area and larger adoptability, frontline demonstrations on Transplanting technology in redgram was conducted in an area of 15 ha compared with local practice during 2008-09. Redgram transplanting technology helped to harvest an average seed yield of 29.70 q per ha with an average grass income and net income of ₹1,24,740 and 1,07,240 per ha, respectively, the cost of cultivation was ₹17,500 per ha. Whereas, it recorded an average yield of ₹17.5 q per ha in traditional practice with an average grass and net income of ₹73,000 and 58,500 per ha respectively and the cost of cost of cultivation in farmers field was ₹15,000 per ha. ICAR-KVK continued conducting further FLDs on redgram transplanting during 2009-10, 2010-11, 2011-12, 2012-13, 2013-14 and 2014-15. All these years, average yield obtained was 27.60 q/ha, gross income of ₹1,13,676/ha and net income of ₹93,176 with transplanted technology whereas it was 15.20 q/ha, ₹62,040/ha and ₹45,540 with farmers practice. Thus, analysis of FLD's data revealed a remarkable 69.71% to 138% increase in yield through the implementation of transplanting technology compared to traditional farming practices followed by farmers. Having achieved the significant yield, redgram transplanting technology was standardized by ICAR-KVK, Bidar which includes preparation of seedlings and transplanting of seedlings in main field.

Flowering stage

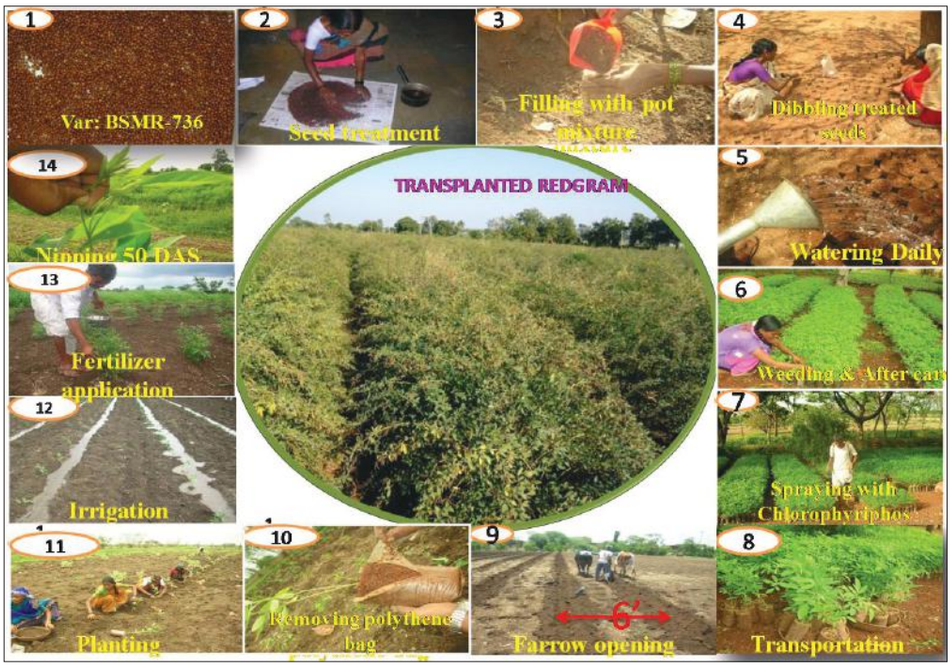
Pod filling stage

Grand growth stage

Farmer with blooming crop

Preparation of redgram seedlings

In the first fortnight of May, the process of preparing seedlings begins with the utilization of 4 × 6 inch polythene bags (150 gauge), requiring approximately 6,050 seedlings per ha. These bags are carefully filled with a pot mixture, creating a conducive environment for germination. The filled bags are then arranged and



Steps involved in redgram transplanting

placed in partial shade, ensuring optimal conditions for the seeds to sprout. Treated seeds are diligently dibbled into the soil, followed by a daily watering routine to nurture the growing seedlings. The process includes regular weeding and aftercare to foster healthy growth. After 30 days, the well-nurtured seedlings are ready for transplantation, marking a critical step in the journey from preparation to the cultivation of robust plants.

Transplanting of redgram seedlings in the field

To cultivate a successful crop, the first step involves land preparation, achieved through a series of essential practices such as ploughing, harrowing, and refining the soil to a fine tilth. Following the onset of the monsoon, furrows are opened at a precise distance of 6 feet apart, creating an optimal environment for the upcoming seedling transplant. Seedlings are then transplanted at a distance of 3 feet, utilizing spot application of FYM (Farmyard manure) or vermicompost. The cultivation process continues with timely weeding and nipping at 30 days after transplanting (DAT). To enhance the crop's nutritional intake, chemical fertilizer is applied using the ring method at a rate of 2.5 bags of DAP (diammonium phosphate) per ha, accompanied by 20 kg of $ZnSO_4$ per ha. Concurrently, proactive plant protection measures are implemented, ensuring the health and vigour of the crop. Irrigation plays a critical role in the cultivation cycle, with crucial stages including flower initiation and pod filling requiring timely watering. Moreover, to mitigate transplanting shock, irrigation is compulsory on the day of transplanting, contributing to the overall success of the cultivation process.

Advantages of redgram transplanting technology

Redgram transplanting technology presents a paradigm shift in agricultural practices, offering a multitude of advantages that cater to the needs of farmers, especially small and marginal ones.

- The method involves advanced sowing, ensuring optimal planting conditions and leading to reduced pod borer damage due to early and efficient planting.
- The deep rooting characteristic enhances drought resistance, a crucial feature in regions prone to water scarcity.
- Notably, this approach facilitates significant savings in seeds, contributing to cost-effectiveness.
- The ease with which plant protection measures can be implemented adds to its appeal, making it a practical choice for farmers.
- Moreover, the technology promotes increased branching, promising a 2-3 fold rise in yield levels, thereby enhancing overall productivity.
- In essence, redgram transplanting technology emerges as a tailor-made solution, aligning with the specific needs of small and marginal farmers, ultimately fostering sustainable and efficient agricultural practices.

Efforts of ICAR-KVK, Bidar for dissemination of redgram transplanting technology

The Krishi Vigyan Kendra Bidar has implemented a multifaceted approach to disseminate redgram transplanting technology, encompassing various channels and initiatives. A robust framework of 85 training programs has been established to educate and empower individuals with the latest technological knowledge. Additionally, 24 field days serve as interactive platforms for practical learning and hands-on experiences. Exhibitions (23), provide a public showcase for cutting-edge technologies. The dissemination strategy extends to the airwaves with 10 radio programs and 18 television programs, reaching a wider audience. Print media is leveraged through 50 publications, while 20,000 leaflets are distributed to further enhance awareness. A CD has been prepared as a comprehensive resource, complemented by 26 mobile messages for timely updates. Furthermore, the organization actively participates in the sale of 200 quintals of BSMR-736 seeds under a revolving fund. In synergy, these initiatives form a cohesive strategy to bridge the technological gap, further augmented by the inclusion of the university calendar.

Horizontal spread of redgram transplanting technology

The horizontal spread of transplanting technology in redgram in Karnataka has witnessed significant expansion, encompassing a vast area of 2,000 ha in Bidar district. This innovative agricultural practice has not only taken root in Bidar but has also proliferated into neighbouring districts such as Kalaburgi, Koppal, Yadgir, Raichur, Vijayapur, Bagalkot, Haveri, Chickmagaluru, and beyond the state borders into Maharashtra, Telangana, Andhra Pradesh, Odisha, Chhattisgarh, and Tamil Nadu. The adoption of transplanting technology has become a catalyst for agricultural advancement, contributing to increased productivity and sustainable farming practices across a diverse geographical landscape.

Recognizing the potential of transplanting technology, redgram farmers in the district have formed associations, envisioning the export of processed dal to neighbouring states and even venturing into international markets. Embracing this cutting-edge technology has positively transformed the living standards of redgram farmers, turning Bidar into the pulse bowl of Karnataka and a symbol of progress and prosperity in agriculture. The district is now witnessing the establishment of numerous redgram processing units thereby creating substantial employment opportunities.

SUMMARY

Redgram is one of the most important commercial crops for dryland farmers in Bidar district of Karnataka. Traditional cultivation practices, improper sowing time, inadequate plant population, defective method of sowing, inadequate intercultural operations, inadequate use of phosphatic fertilizers and improper method of application are the major agronomic constraints due to which productivity is declining. In this regard, ICAR-KVK, Bidar initiated a trial on transplanting of Redgram after a collaborative discussion and brainstorming session with progressive farmers and ICAR-KVK scientists in 2004-05 that led to achieving promising results. Subsequently, ICAR-KVK, Bidar has made efforts and conducted various activities like OFTs, FLDs, capacity building, farm advisories and services. As a result, Redgram transplanting technology was standardized.

The technology involves meticulous process of preparing seedlings through polythene bags and careful germination management, leading to healthy seedlings ready for transplantation after 30 days in the main field. The adoption of transplanting technology has enabled farmers to tap into the maximum yield potentiality of redgram that resulted unprecedented yields than they had previously obtained. Once a neglected crop, redgram has become a major commercial crop through this technology now. Overall, the success of this technology in Bidar district showcases its potential to revolutionize redgram cultivation especially in dryland significantly enhance farmers' livelihoods.

The Redgram transplanting technology has not only taken root in Bidar but has also proliferated into neighbouring districts and beyond the state borders. As redgram transplanting technology offers numerous advantages, it became a resource effective crop production approach to unleash the potential yield of redgram and tailor-made solution that aligns with the specific needs of small and marginal farmers of dryland farming in Bidar district of Karnataka in particular as well as in other districts of Karnataka and other states across the country in general.

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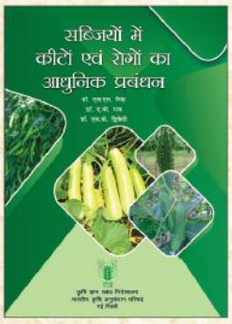
ICAR New Arrivals



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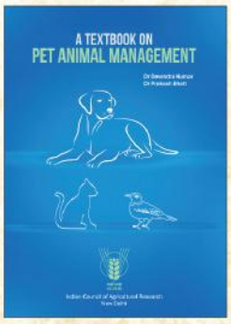

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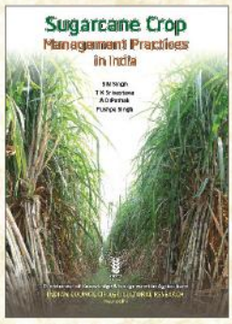

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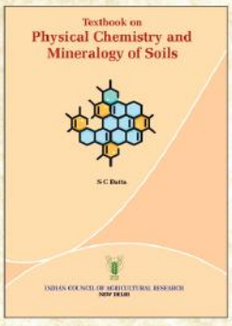

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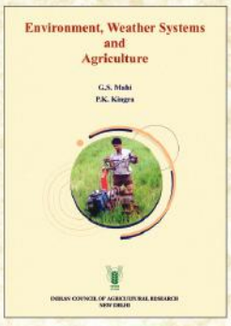

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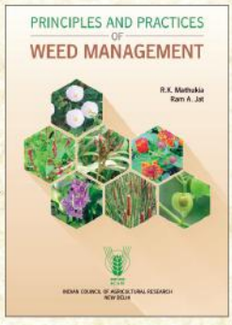

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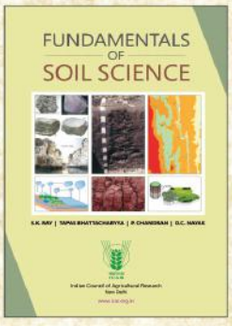

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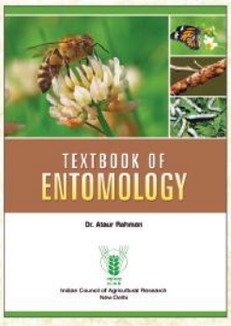

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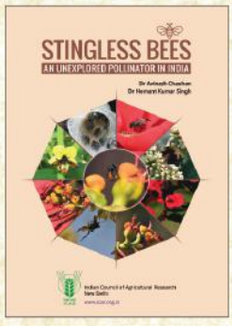

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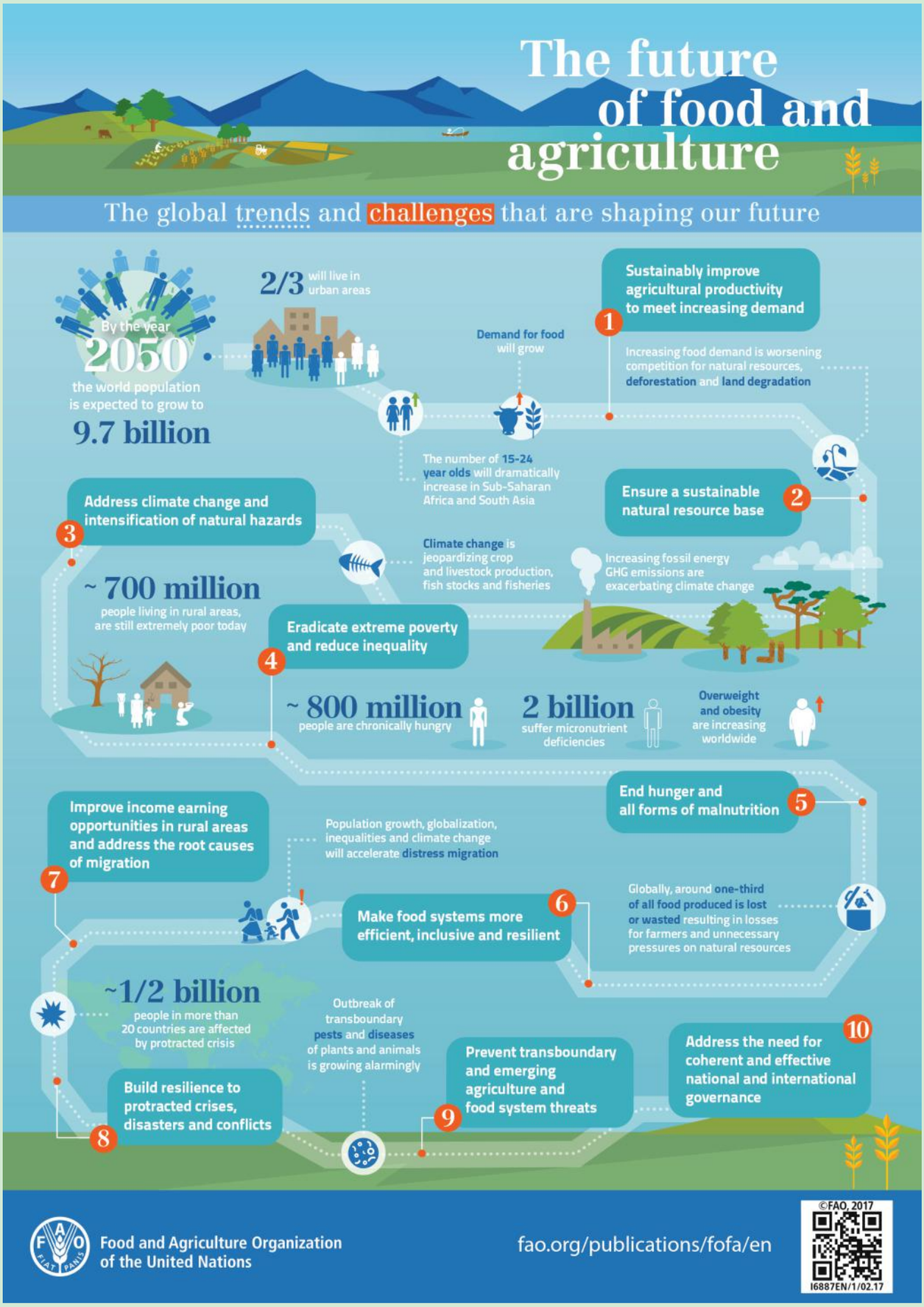

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