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NRCSS

Biotech Kisan Hub for Western Dry Region

Sustainable Practices for Quality Production of IPM CUMIN

(*Cuminum cyminum* L.)

Bhagirath Choudhary*, SS Meena**, MD Meena**, Shiv Lal**, Neha Bulchandani*, Sandip Agale*, Naresh*, Shreya Mishra* & KS Bharadwaj*

*South Asia Biotechnology Centre (SABC)

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Message

Dr Vinay Bhardwaj
Director, ICAR-National Research Centre on Seed Spices (NRCSS)
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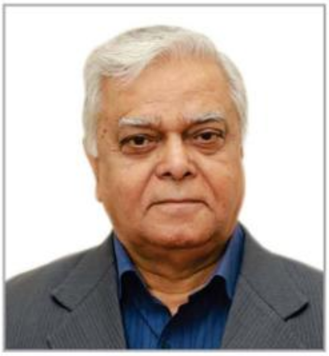
It is my privilege to present this report on cumin, a pivotal seed spice shaping India's agricultural and economic landscape. As the world's largest producer and exporter of cumin, India accounts for over 70% of global production, with approximately 11.88 lakh hectares under cultivation and an annual output of around 8.6 lakh metric tons. Valued at over 5,797 crores export, cumin is a cornerstone of India's spice export portfolio, enhancing farmer livelihoods and bolstering the nation's global reputation.

The ICAR-National Research Centre on Seed Spices (NRCSS) in collaboration with South Asia Biotechnology Centre (SABC) has spearheaded efforts to address the challenges faced by cumin growers while promoting sustainable farming practices. Through the biotech kisan hub project (2020–2023), implemented across Western Rajasthan, the Centre conducted 47 Integrated Pest Management (IPM) field demonstrations, 6 trainings, 3 field days, 1 workshop and 1 farmers scientist interaction meet in key cumin-growing districts. These initiatives directly benefited approximately 4,914 farmers, including both men and women, by showcasing residue-free cumin production techniques.

Essential resources were supplied to farmers under this project, including high-quality seeds of improved cumin varieties, bio-kits comprising botanical and microbial solutions, sticky traps, and approved plant protection products. Additionally, plant growth regulators and tarpaulins were distributed to aid in the safe handling and storage of produce, ensuring pesticide-residue-free cumin.

Our initiatives have emphasized the adoption of good agricultural practices (GAP) and good hygiene practices (GHP). By facilitating soil and water health testing, on-field training, and timely advisories, we have empowered farmers to align their practices with international quality standards. Digital platforms, training sessions, and kisan melas have further supported knowledge dissemination, promoting sustainable, market-driven cumin cultivation.

ICAR-NRCSS continues to champion innovations in genetic improvement, agronomic practices, and climate-resilient strategies. As we advance, ICAR-NRCSS remains steadfast in fostering sustainable growth, bridging research with real-world applications, and enhancing India's stature in the global spice trade. This report encapsulates our achievements and reaffirms our vision of driving excellence in seed spices research and development.



Foreword

Dr CD Mayee,
President, South Asia Biotechnology Centre, Jodhpur

Indian agriculture has consistently thrived on its ability to adapt, innovate, and implement cutting-edge technologies to achieve sustainability and profitability. Despite my specialization in plant pathology, my journey has been dedicated to the holistic growth of Indian agriculture. Through research, publications, and active engagement with students and the farming community, I have endeavored to support the development of resilient production systems for crops like cotton, groundnut, coarse cereals, and oilseeds. The spice sector, particularly cumin, holds similar transformative potential in India's agricultural landscape, which is unfolding in Western Rajasthan under Biotech kisan hub supported by the Department of Biotechnology (DBT) of Government of India.

The book "Sustainable Practices for Quality Production of IPM Cumin (*Cuminum cyminum L.*)" is a testament to the commitment of the agricultural research community toward sustainable spice production. Cumin, an iconic crop for the arid and semi-arid regions of India, particularly Rajasthan and Gujarat, is both a valuable economic asset and a symbol of India's global spice trade. With the increasing demand for quality, residue-free spices globally, adopting sustainable and scientific practices has never been more crucial.

Under the aegis of DBT's Biotech Kisan Hub for Western Dry Regions, remarkable strides have been made in promoting cumin as a high-potential spice crop. This initiative has emphasized the adoption of integrated pest management (IPM) practices, which ensure pest control while safeguarding the environment and consumer health. The hub has not only trained farmers in residue-free cumin production but also highlighted the need for ecosystem-friendly methods, ensuring the long-term viability of cumin cultivation in Rajasthan and developing value chain system to improvise price realization to smallholder farmers of Rajasthan.

The IPM approach, as elaborated in this document, underscores a balanced integration of cultural, physical, biological, and chemical pest management practices. With adherence to core principles like pest surveillance & monitoring, understanding ecosystem dynamics, economic threshold levels (MRL), and judicious pesticide use, IPM ensures that cumin growers produce high-quality, market-ready crops while conserving natural resources.

The global market for spices is witnessing unprecedented growth, and India is well-positioned to lead this revolution. Cumin, a cornerstone of Indian spices, has the potential to further solidify the nation's position as the global spice trade. The sustainable practices detailed in this document empower farmers to adopt good agricultural practices (GAP) and IPM-based production systems, creating pathways for world-class quality, food safety, and robust market linkages.

I commend the authors for this valuable contribution to the spice production literature. This document is not just a guide for cumin farmers but a visionary effort that aligns with India's goals of sustainable agriculture and enhanced global competitiveness. It is my firm belief that the practices promoted herein will pave the way for a brighter, more sustainable future for cumin cultivation, contributing significantly to the economy and livelihoods in the arid regions of Rajasthan.

Preface

Authors:
Bhagirath Choudhary, SS Meena, MD Meena, Shiv Lal, Neha Bulchandani, Sandip Agale, Naresh, Shreya Mishra & KS Bharadwaj

Cumin (*Cuminum cyminum L.*) is a remarkable spice revered for its distinct aroma, flavor, and medicinal value, finding its place in both Indian and global markets. It is a vital crop in Rajasthan, flourishing in the arid, sandy soils and unique climate of the state's western regions. However, cumin cultivation requires precision, specific agronomic practices, and sensitivity to pest and disease management, making it both an opportunity and a challenge for farmers. Recognizing this, the Department of Biotechnology under Government of India launched the Biotech Kisan Hub for Western Dry Region in 2020 to initiate and support cumin cultivation farmers of Western dry region. This initiative aimed at increasing the production of high-quality, residue-free cumin through the adoption of good agricultural practices (GAP) and integrated pest management (IPM) practices, aligning with international food quality and safety standards.

The South Asia Biotechnology Centre (SABC), Jodhpur along with a team of scientists of ICAR-National Research Centre on Seed Spices (NRCSS), Ajmer who have dedicated years of research and development to advancing cumin as a key seed spice with its groundbreaking record of extension activities helped transforming cumin into a cornerstone crop for the desert regions of Rajasthan.

This document presents a comprehensive study of cumin—from its biology and cultivation techniques to the latest advancements in integrated pest management (IPM) and good agricultural practices (GAP) highlighting the role of Biotech Kisan Hub in advancing the IPM cumin farming system. We hope that this work will serve as a valuable reference for farmers, researchers, policymakers, and traders alike, offering insights into the sustainable production of high-quality IPM cumin that meets international food safety and quality standards.

We are deeply grateful to Dr Rajesh S Gokhale, Secretary, Department of Biotechnology (DBT), Govt of India, Dr H.S. Gupta, Chairman, Project Steering and Management Committee (PSMC) and Dr Nita Khandekar, mentor of the project for establishing the Biotech Kisan Hub for Western Dry Region at Jodhpur, Rajasthan. Our efforts have been greatly enriched by the invaluable support of Dr. Gopal Lal and Dr S.N. Saxena, former Director of ICAR-NRCSS and Dr Vinay Bharadwaj, Director of ICAR-NRCSS, Ajmer. Moreover, we would like to acknowledge and appreciate the contribution of researchers, scientists and officials of ICAR-NRCSS, the Spices

Board of India and the Agricultural and Processed Food Products Export Development Authority (APEDA). Large scale adopting the package of practices developed by ICAR-NRCSS to meet international standards and bringing their pioneering research, particularly through their collaboration with the Biotech Kisan Hub initiative, that has laid a strong foundation for expanding cumin production using IPM-based, residue-free practices. ICAR-NRCSS's contributions to genetic improvements, pest and disease control, and scalable agronomic practices have been instrumental in shaping the "lab-to-land" approach that is now empowering farmers across Rajasthan. The Biotech Kisan Hub project, with its resources such as high-quality seeds, bio-kits, sticky traps, plant protection products, and field demonstrations, has brought scientific advancements to the field level, enhancing the livelihoods of thousands of farmers by boosting yields and crop quality. Linking farmers to value chain partners have been the second most important outcome of the hub involving Rajasthan State Agricultural Marketing Board (RSAMB), Krishi Vigyan Kendra (KVKs), State Agricultural University (SAUs), Farmers Producer Organization (FPOs), private sector companies such as ITC Ltd, SRK Spices and Bayer CropScience and industry associations such as Federation of Indian Spice Stakeholders (FISS) and Rajasthani Association of Spices (RAS).

The successful extension activities organized jointly by ICAR-NRCSS and South Asia Biotechnology Centre, Jodhpur, including on-farm training sessions, kisan melas, and digital outreach, have also fostered a community of knowledge-sharing and skill-building for sustainable cumin farming. Through this book, we acknowledge and extend our heartfelt gratitude to ICAR-NRCSS, Ajmer, whose support and collaborative spirit have been invaluable to the success of this initiative.

In writing this document, our hope is to contribute to the growing recognition of Rajasthan's cumin as a premium, sustainably produced spice to meet the growing demand for pesticide residue free cumin in both domestic and international markets. The extensive field demonstrations and the IPM cumin production methods outlined here provide a pathway for achieving greater market value, economic benefits, and international recognition for Indian cumin branded as IPM cumin. We are confident that this book will serve as a source of guidance and inspiration, furthering the understanding and appreciation of cumin's agronomic and economic importance.

Executive Summary

Known for its dietary, nutritive and health benefits, cumin (*Cuminum cyminum L.*) is recognized as a leading seed spice crop with significant potential in both domestic and export markets. Cumin thrives in moderate growing conditions however, it is inherently sensitive to biotic and abiotic stresses. Within such conditions, Rajasthan and neighbouring Gujarat have emerged as the *cumin bowl of India*, cultivating this crop across vast tracts of arid land. Together, these two states contribute nearly 99% of India's total cumin production, underscoring the crop's regional specificity and adaptive niche.

Over the years, the area under cumin cultivation has expanded significantly from 5.21 lakh hectares in 2004–05 to 11.85 lakh hectares in 2023–24, nearly doubling in two decades. However, productivity varies widely as Gujarat yields around 980 kg/ha while Rajasthan averages 520 kg/ha in 2023–24. Cumin seeds and their by-products are exported to over 25 key countries, showing remarkable gains in both quantity and value. Nearly 30% of India's cumin is exported, earning 5,797 crore in 2023–24 and 6,178 crore in 2024–25.

Given its immense potential and multiple virtues, the Department of Biotechnology (DBT) felt an urgent need to promote technical approaches that are economically, environmentally, and socially sustainable for producing high-quality cumin. The export of residue-free and IPM-grown cumin depends on healthy and hygienic production systems that can meet the stringent quality standards of international markets.

To achieve this, the Biotech-KISAN Hub for the Western Dry Region, supported by the Department of Biotechnology (DBT), Government of India, has implemented an integrated approach to cumin farming and value chain development. The Hub has generated modules and promoted packages of practices developed by the ICAR–National Research Centre on Seed Spices (NRCSS), Ajmer. It has conducted numerous field demonstrations, on- and off-field training programs, Kisan Melas, and stakeholder mobilization activities focusing on cumin in the districts of Jaisalmer, Barmer, Jodhpur, Nagaur, Pali, Jalore and Jalore of Western Rajasthan. The Hub distributed essential inputs including quality seeds, microbial formulations and botanicals as bio-kits, sticky traps, CIBRC-approved plant protection products, plant growth regulators and tarpaulins to support residue-free cumin production. It also facilitated technical pamphlet distribution, soil and water testing, timely advisories and on-farm training to ensure implementation of Good Agricultural Practices (GAP) and Good Hygiene Practices (GHP) across farmers' fields.

Further, the Biotech Kisan Hub mobilized a wide range of stakeholders including KVKs, State Agricultural Universities (SAUs), local government departments, Rajasthan State Agricultural Marketing Board (RSAMB) and trade promotion agencies such as APEDA and the Spices Board of India. The downstream industry including ITC, SRK Spices, Swani Spices, Rapid Organics, BKB Industries, PJM Industries, Janta Global and the Federation of Indian Spice Stakeholders (FISS) also partnered actively, alongside local organizations such as the Ambuja Cement Foundation and Balaji Farmer Producer Organization (FPO). The Hub has organized numerous training programs covering all aspects of sustainable cumin production, engaging farmers and stakeholders across multiple locations. Dissemination of information through WhatsApp groups and the Biotech-KISAN Hub website has played a crucial role in amplifying the adoption of GAP and IPM practices across Western Rajasthan. All resources generated under the Hub are available at www.biotechkisan.org

The key outcomes of the project include the residue-free production of cumin, reduction in pesticide use, enrollment of farmers under Internal Control Systems (ICS) and procurement of IPM cumin based on food safety testing. The Hub also recorded significant progress in the number of samples tested and the volume of IPM cumin procured by private companies.

The economic impact of the project was demonstrated through exemplary farmers adopting GAP and IPM practices for residue-free cumin production. The socio-economic impact was quantified with support from ICAR-NRCSS, showing area-wide adoption and diffusion of IPM technologies. The Hub's initiatives enabled buy-back arrangements through FPOs to ensure farm-gate procurement. Farmers in Budi Arjunapura signed buy-back agreements with M/s SRK Spices Pvt. Ltd., while those in Pali collaborated with M/s ITC Pvt Ltd. On average, IPM cumin fetched a 24% premium over the market price for demonstration farmers, while reducing the cost of production by 25–35% per acre through effective management of fungal diseases and insect pests.

Consequently, the GAP and IPM-based production model has proven to be a viable, sustainable approach for producing residue-free cumin and has led to the successful popularization of the "IPM Cumin" brand across Western Rajasthan.

By 2023–24, private companies such as ITC, McCormick, AVT McCormick, Ned Spices, Rapid Organic, Janta Global, PJM and SRK Spices collectively procured an estimated 37,500 metric tonnes of IPM cumin, based on 10,700 residue tests, from key cumin-growing districts of Barmer, Jaisalmer, Sanchore, Jalore, Nagaur and Jodhpur. This large-scale farm-gate sourcing reflects not only the quality of the produce but also the rising income and improved financial prospects of cumin farmers.

During the Biotech kisan hub implementation period, the market price of cumin in Western Rajasthan rose sharply from 18,000 per quintal in 2019–20 to a peak of 45,000 per quintal in 2022–23, later stabilizing around 25,000 per quintal in 2023–24, coinciding with widespread adoption of IPM technology and improvement in production quality over the last 4–5 years.

The DBT Biotech-KISAN Hub continues to actively engage with cumin farmers in Western Rajasthan to sustain project momentum. It also shares its knowledge and experiences through platforms such as the WTO–FAO STDF program of the Spices Board of India, FISS (Unjha), and the Rajasthan Association of Spices (RAS), Jodhpur along with private-sector partners involved in cumin procurement. The Hub further provides water and soil testing facilities and technical support on GAP and IPM-based production and procurement grounded in food safety testing. These ongoing efforts are ensuring the long-term sustainability and self-reliance of cumin farmers in the Western dry region of Rajasthan.

Table of Contents

Acronyms & Abbreviations

%	= Percentage
⩽	= less than or equal to
Inch	= Inches
µg	= Micro grams
mm	= Millimeter
cm	= Centimeter
m	= Meter
ac	= Acre
ha	= Hectare
g	= Gram
kg	= Kilograms
q	= Quintal
t	= Tonnes
Mt	= Metric ton
ppm	= Part per million
ml	= Milliliter
lit	= Liter
No.	= Number
i.e.	= That is
sp.	= Species
°C	= Degree Celsius
eg	= As for example
ha	= Hectare
etc	= Et cetera
pH	= Potential of Hydrogen
AGMARK	= Agriculture Marketing
APEDA	= Agricultural and Processed Food Products Export Development Authority
ASTA	= American Spice Trade Association
CAC	= Codex Alimentarius Commission
CFU	= Colony Forming Units
CIBRC	= Central Insecticide Board and Registration Committee
CONTAM	= Contamination control
DBT	= Department of Biotechnology
DAS	= Days After Sowing
ECR	= European Commission Regulation
ESA	= European Spice Association
ETO	= Ethylene oxide

FISS	= The Federation of Indian Spice Stakeholders
FAO	= Food and Agriculture Organization
FPO	= Farmers Producer Organization
FISS	= Federation of Indian Spice Stakeholders
FSSAI	= Food Safety and Standards Authority of India
FYM	= Field Yard Manure
GAP	= Good Agricultural Practices
GCC	= Gulf Cooperation Council
GHP	= Good Hygiene Practices
GOI	= Government of India
HACCP	= The Hazard Analysis Critical Control Point
HAP	= Hazardous Air Pollutant
IARI	= Indian Agriculture Research Institute
ICAR	= Indian Council of Agricultural Research
IPM	= Integrated Pest Management
ISO	= International Organization for Standardization
ITC	= Indian Tobacco Company
JMPR	= Joint Meeting on Pesticide Residues
KVK	= Krishi Vigyan Kendra
LOQ	= Limit of Quantification
MRL	= Maximum Residue Limit
NABARD	= National Bank for Agricultural and Rural Development
NAA	= Naphthalene Acetic acid
NRCSS	= National Research Centre on Seed Spices
PAs	= Pyrrolizidine alkaloids
PANOs	= Pyrrolizidine alkaloids N-oxides
PHI	= Pre-Harvest Interval
POP	= Package of Practices
PPE	= Personal Protective Equipment
RAS	= Rajasthani Association of Spices
RD	= Recommended dosage
RH	= Relative humidity
RSAMB	= Rajasthan State Agricultural Marketing Board
SABC	= South Asia Biotechnology Centre
SAU	= State Agriculture University
SRK	= Shree Radhey Krishna Spices
USDA	= U.S. Department of Agriculture
US EPA	= U.S. Environmental Protection Agency
WHO	= World Health Organization

Introduction

1.1 Biotech-KISAN Hub for the Western Dry Region

India holds a commanding position in the global spice trade, both in terms of volume and value. Value-added seed spice products, along with raw materials, contribute nearly 50–60% of the total global spice demand. Within India, Rajasthan and Gujarat are widely recognized as the major cumin-producing states covering vast geographical areas of the Western dry region of Rajasthan, including the districts of Barmer, Jaisalmer, Jalore–Sanchore, Jodhpur, Nagaur and Pali.

These districts produce large quantities of cumin, but the crop often suffers from pesticide residues and other quality-related issues such as dust admixture, diseased or moistened seeds, unripe grains, and other physical contaminants. The presence of pesticide residues and impurities has emerged as a major barrier to export, primarily due to the strict quality standards imposed by importing countries. Furthermore, cumin productivity remains abysmally low, largely due to poor germination and sub-optimal plant density.

To address these challenges and promote an Integrated Pest Management (IPM)-based cumin farming system, the Department of Biotechnology (DBT) of the Government of India established the Biotech-KISAN Hub for the Western Dry Region at the South Asia Biotechnology Centre (SABC), Jodhpur in collaboration with the ICAR–National Research Centre on Seed Spices (NRCSS), Ajmer. The Biotech-KISAN Hub successfully implemented large numbers of activities in major cumin-growing districts of Rajasthan from 2020 to 2023 aimed at enhancing the quality of production, processing, value chain development and export potential of cumin.

1.2 Cumin- The Pride of India's Seed Spice Basket

Globally, cumin (*Cuminum cyminum* L.) is referred to as the second most important seed spice followed by chilli. It is an herbaceous annual plant, commonly called jeera in India. Cumin seeds are characterized for its flavor and aroma and are categorized into three types of colors such as amber (most common), white and black. Moreover, cumin seeds find universal usages in foods, beverages, medicines, perfumery and toiletries etc. In Indian kitchens, cumin is used for a series of preparations by adding flavor, aroma and other nutritional virtues. Traditionally, cumin is known for its health benefits and aids in curing some disorders such as morning sickness, biliousness, indigestion, atomic dyspepsia, diarrhea, flatulent colic and malabsorption syndrome.

Cumin is one of the oldest crops known as a minor spice used by mankind for culinary, dietary and health benefits. The Romans and Greeks used cumin medicinally and cosmetically in view to introduce pallid complexion. The cumin spice has been associated with Moroccan inhabitants being abundantly used for routine street cooking and medicinal preparations. For instance, Indians, Pakistanis, Middle Eastern, North Africans, Sri Lankans, Cubans, Sichuan's and Xingjian Yan inhabitants and several other countries and communities have been using it in distinctive manners for desired benefits.

Cumin is a world known seed spice. Currently, it is largely cultivated in India (70%), Syria (13%), Turkey (5%), United Arab Emirates (3%) and Iran (3%). Cumin is the largest grown spice in India covering 9.02 lakh ha area, producing 6.27 lakh ton cumin seed during 2022-23. India is the largest producer, consumer and export of cumin in world. India produces about 70% of the world's cumin and exports (2.29 lakh ton) to more than 150 countries, catering nearly 80% of world cumin demand, by sparing 25 to 30% of annual production.

The cumin plant is 20 to 30 cm tall bearing 4 to 5 mm long fruit, containing a single seed which is arranged in an umbel structure. The seeds are 3 to 6 mm long and come as either paired or separate carpels. They are boat-shaped, tapering at each extremity with tiny stalks attached to them. They have a striped pattern of nine ridges and oil canals, and are yellow brown in color, like other members of the *Apiaceae:* family such as caraway, parsley and dill. Figure 1 shows the morphological appearance of cumin crop, as demonstrated in the farmers' field of the hub of Western dry region.

Figure 1: Morphological appearance of cumin crop

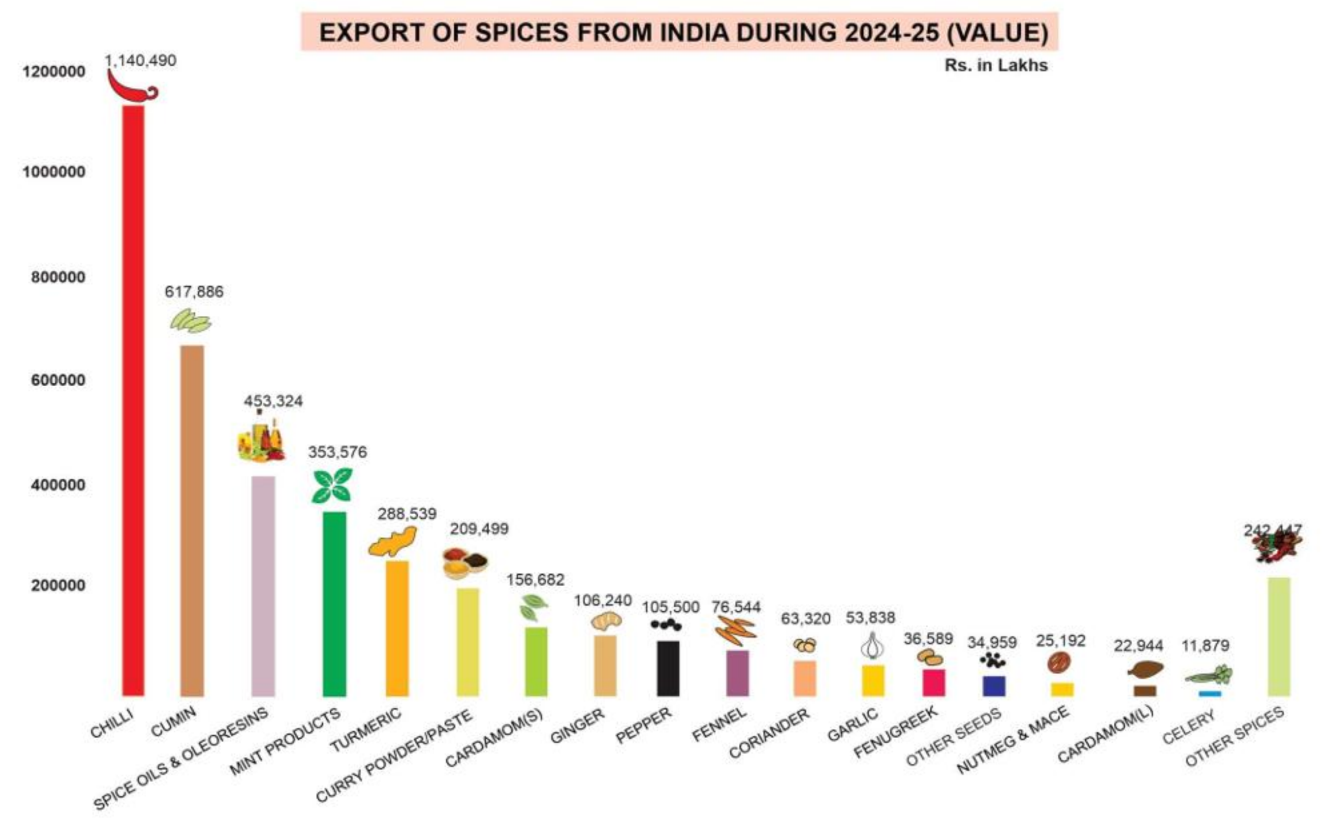
Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2021

The Status of Spices and Cumin Production in India

In the last two decades, India has achieved a remarkable feat in the production of spices over 4.73 million hectares producing 11.8 million tons of Spices in 2023-24 from 3.15 million hectares producing 4.0 million tons in 2004-05. The country has doubled the productivity of spices from 1.27 tons per hectare in 2004-05 to 2.49 tons per hectare in 2023-24. Moreover, the spices sector has grown many folds in the last two decades with record export of spices at 1.79 lakh tons in 2024-25, quintupling from 0.35 million tons in 2004-05. In value terms, the export of spices was estimated at US$4.7 billion equivalent to ₹39.99 crores in 2024-25, attaining a record in terms of both volume and value over the previous years.

Notably, the percentage of export to domestic production is barely 13.0% with a tremendous scope to enhance production, processing and value addition of exportable spices from India. The basket of the scheduled spices notified by the Spices Board of India has increased to 52 spices including notified spices in last two decades with a tremendous opportunity to expand the basket of spices with seeds spices, aromatic and medicinal spices, geographical indication (GI) spices, tree spices and other minor spices grown exclusively by tribal, marginalized and under-privileged community for income and livelihood in the remote areas of the country.

Figure 2: The export of spices from India, 2024-25 (in Lakhs)

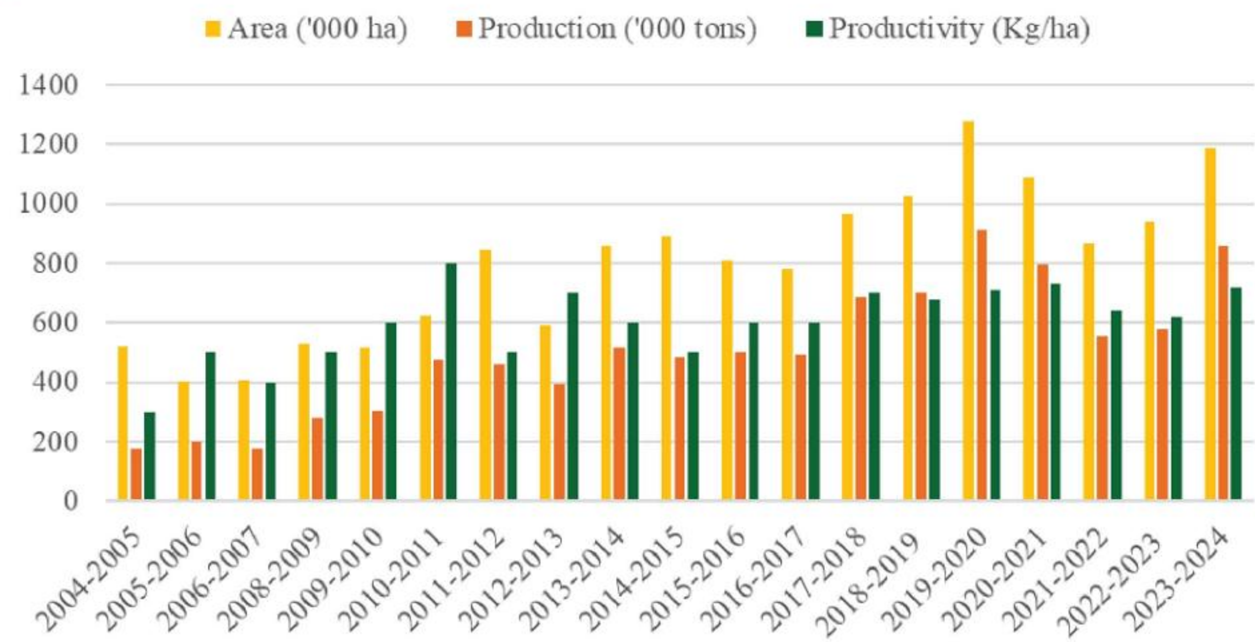


Source: Adapted from the Spices Board of India, 2025

2.1 Cumin - The crown of spices

Cumin is number one seed spice and finds a prominent place in the list of scheduled spices notified by the Spices Board of India such as black chilli, pepper, ginger, turmeric, garlic, cardamoms, coriander, fenugreek, fennel, celery, ajwain, clove, dill seed, saffron, curry leaf, mint and tamarind etc. These spices, including cumin, have great socio-economic significance and contribute significantly in the export of agricultural commodities from India. Cumin is mainly cultivated in Rajasthan and Gujarat, and some parts of Madhya Pradesh, Uttar Pradesh and West Bengal. India recorded an average production of 8,60,090 metric tons from 11.87 lakhs ha with productivity of 720 kg per hectare in 2023-24. Rajasthan and Gujarat together contribute 99% of the national cumin production. Rajasthan grows cumin over 6.55 lakh ha whereas Gujarat grows 5.30 lakh ha area producing 3.39 lakh tons and 5.18 lakh tons in 2023-24, respectively. Barmer, Jodhpur, Jalore, Nagaur, Jaisalmer and Pali are the top cumin growing districts of Rajasthan, which contribute around 95% and 79% to states area and production. Similarly, about 79% and 66% of Gujarat's area and production of cumin yield from Surendranagar, Banaskantha, Patan, Jamnagar, Rajkot and Kutch districts respectively. However, the productivity of cumin in Rajasthan at 520 kg/ha is almost half of Gujarat productivity at 980 kg/ha, exhibiting a crucial difference. Being a commercial & export-oriented spice crop, smallholder farmers of Rajasthan and Gujarat prefer to grow cumin in irrigated arid zones.

Figure 3: Area and production of cumin in India, 2004-05 to 2023-24



Source: The Spices Board of India, analyzed by South Asia Biotechnology Centre, 2024

The area and production of cumin at the national level in 2023–24 was 11.7 lakh hectares and 8.6 lakh tons, respectively. Notably, the area and production under cumin have registered a significant growth from 5.21 lakh hectares and 1.76 lakh tons in 2004–05, an increase of 2.25 times in area and 4.88 in production. At the same time, the productivity of cumin has increased by 140% by 2023–24 as compared to 2004-05 (Figure 3). The time series data for the last two decades shows that cumin production and productivity has improved tremendously by the large-scale adoption of improved technology by smallholder farmers of Western dry region, the epicenter of cumin production in India.

2.2 Export destination and potential

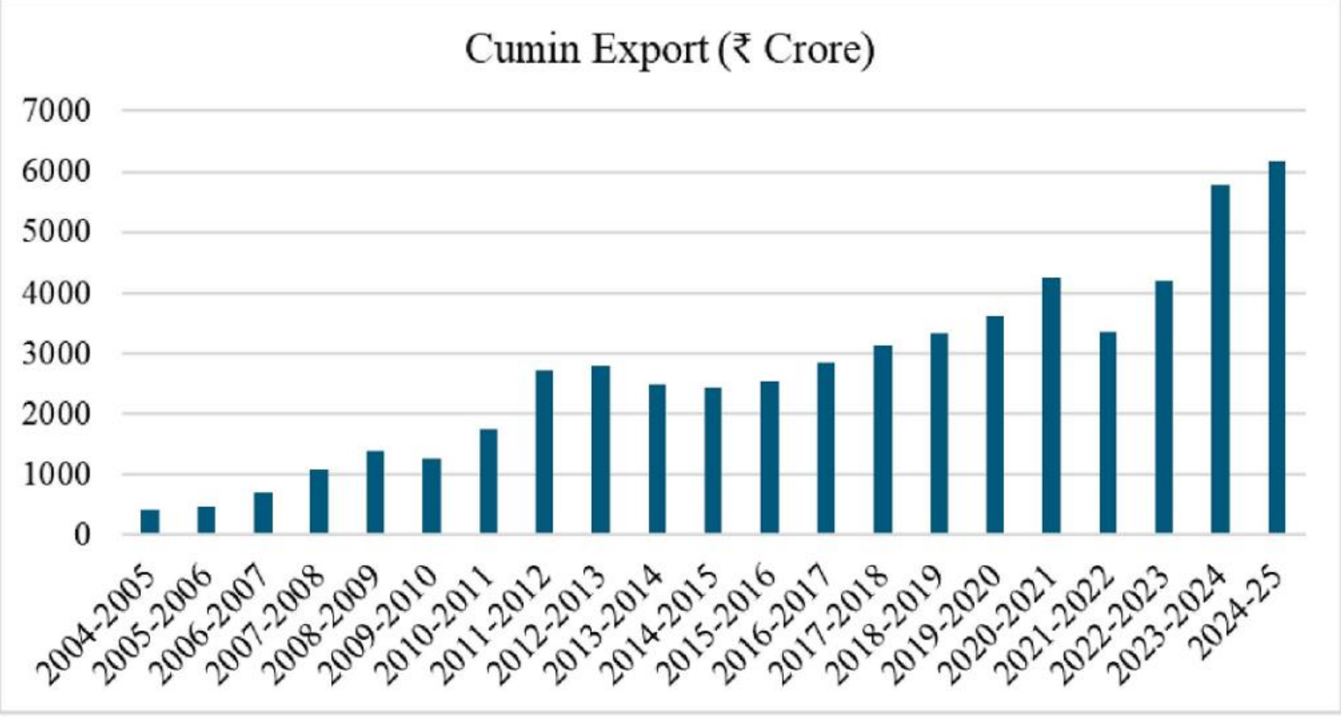
Cumin from Gujarat and Rajasthan is exported to more than 20 countries including China, Bangladesh, USA, EU, South Africa, Nepal, Saudi Arabia, Afghanistan, Egypt, UAE, Morocco, Pakistan, UK, Malaysia, Brazil, Mexico, Japan, Sri Lanka etc. Figure 4 shows the export of cumin in terms of value (in US$ millions) from 2004-05 to 2023-24.

Table 1: Major cumin importing & competing countries

Major cumin importing countries	China, Bangladesh, USA, EU, Morocco, Pakistan, UK, Mexico, Egypt, UAE, Nepal, Malaysia, Brazil and Saudi Arabia
Major competitor for cumin export	Syria, China, Pakistan, Iran, Turkey

The bulk of national production of cumin is used for domestic consumption whereas around 2,29,881 metric tons equivalent to almost 30% is exported generating roughly ₹ 6,178.8 crore to Indian exchequer in 2024-25. China followed by Vietnam and Bangladesh is the largest importer of cumin from India with others importing cumin including the United States of America, European Union, the United Arab Emirates and Nepal. India's main competitors in the export market for cumin are Turkey, Iran and Syria. The by-products of cumin seeds like oleoresins and cumin oil are also exported to the United States of America, Canada and Europe. Figure 4 clearly revealed that the quantity and value of export of cumin has increased from 15,767 tons and ₹ 115.3 crores in 2004-05 to 186,509 metric tons and ₹ 4,193 crores in 2022-23, 1,65,269 tons and ₹ 5,797 crores in 2023-24, and 2,29,881 tons and 6,178.8 crores in 2024-25, (Figure 4).

Figure 4: Trend in export of cumin in value term (in US$ millions) from India, 2004-05 to 2024-25



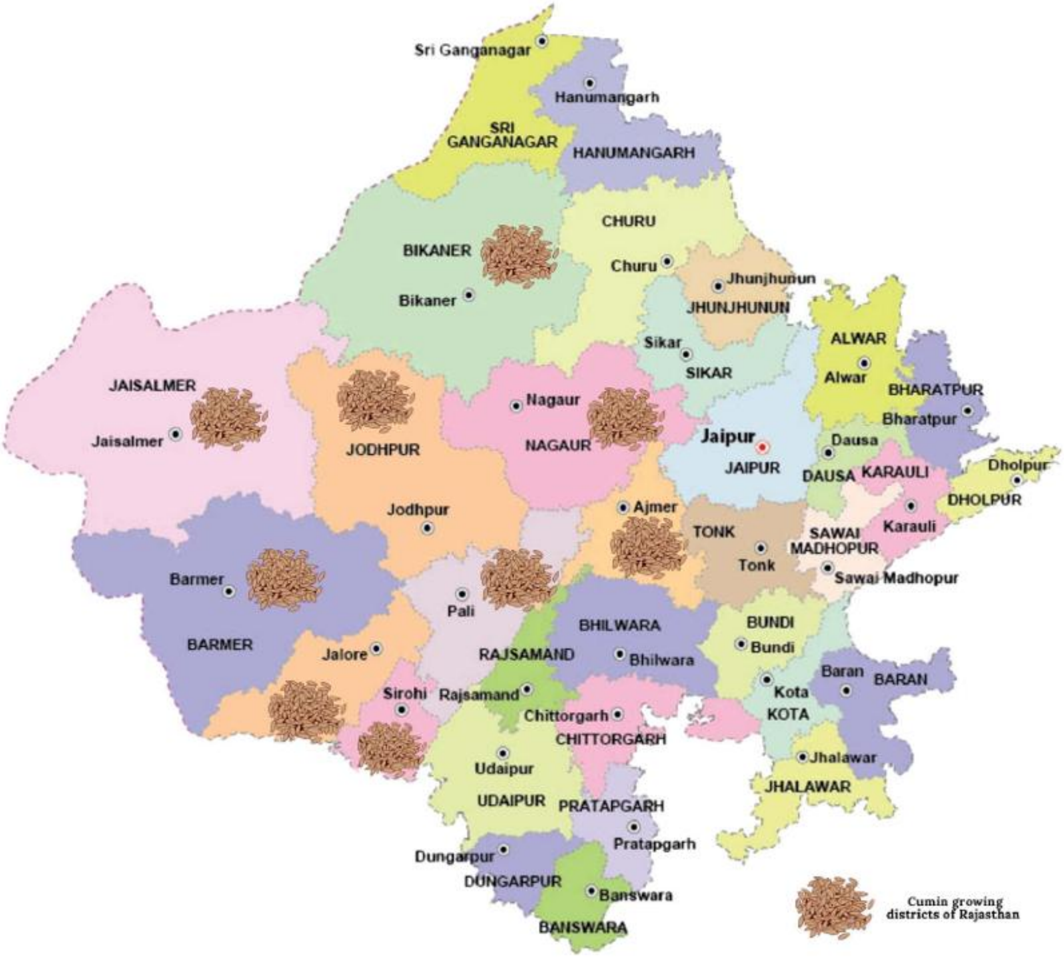
Source: Spices Board of India, analyzed by South Asia Biotechnology Centre, 2025

2.3 Rajasthan - The epicenter of cumin production

Rajasthan grows cumin over 6.5 lakh ha and produces 3.39 lakh tons with an average productivity of 520 kg per hectare. Cumin is grown primarily in Western dry region covering 2.08 lakh hectares in Barmer, 1.91 lakh hectares in Jodhpur, 1.37 lakh hectares in Jalore, 1.05 lakh hectares in Jaisalmer, 0.83 lakh hectares in Nagaur and 0.23 lakh hectares in Bikaner. The highest productivity of cumin is recorded at 749 kg per hectare in Jodhpur whereas as lowest at 385 kg per hectare in Bikaner. Other major cumin producing districts with the record productivity of 415 kg per hectare in Barmer, 452 kg per hectare in Jaisalmer and 460 kg per hectare in Jalore.

Of the total cumin production in Rajasthan, Jodhpur produces 1.43 lakh tons cumin whereas Barmer produces 0.86 lakh tons in spite of having a maximum area 2.08 lakh ha with very low productivity of 418 kg per hectare. There has been a notable variation in the productivity across different districts with the productivity gap of 364 kg per hectare between the highest and lowest productivity district. The State of Rajasthan has huge potential to increase cumin production if the productivity of low yielding districts of Barmer, Jaisalmer, Jalore and Bikaner can be improved significantly. The other way to improve production is to increase area under cumin in the high productivity districts of Pali at 767 kg per hectare, Nagaur at 695 kg per hectare, Sirohi at 678 kg per hectare and Ajmer 588 kg per hectare.

Figure 5: Major cumin producing district in Rajasthan



2.4 Challenges in cumin production

India being a major exporter of cumin is facing numerous challenges with respect to sanitary and phytosanitary (SPS) measures, particularly on pesticide residue from the importing countries especially European Union, USA and China. Keeping in view the international standards and quality norms, the domestic production should be geared to increase the adoption and popularization of good agricultural practices (GAP) to produce residue free IPM cumin to meet domestic and international quality standards. For the past 4 years, the Biotech Kisan Hub along with ICAR-NRCSS and other key stakeholders have been guiding smallholder farmers to comply with international quality parameters and exercise precautions in the production system. Encouraged by technical guidance and handholding, farmers tend to follow GAP, IPM and GHP from field preparation, cultivation, harvesting and threshing of the crop. Similarly, the post-harvest management practices have received adequate attention to reduce contamination and other mechanical injuries by adopting technical measures such as machine harvesting & threshing, tarpaulin drying, proper grading, storage and packaging of the produce. The Biotech Kisan Hub has been emphasizing the promotion and adoption of GAP, IPM and GHP during pre-harvest and post-harvest specific to growth and harvesting stages. Moreover, the project has generated enormous knowledge resources on production techniques and quality standards in local language to relay right information among growers, processors, traders, marketers and exporters. The future of cumin farmers in the Western dry region depends heavily on the large-scale adoption and success of IPM cumin harvest, which has potential to make India an epicenter of cumin export to the world.

The cumin document "Sustainable Practices for Quality Production of IPM Cumin (*Cuminum cyminum* L.) is the culmination of knowledge and field experience in the successful implementation of the Biotech Kisan Hub for Western Dry Region from 2020 to 2023. The document is as a repository of knowledge on cumin aimed at unlocking opportunities to enhance the quality of production and surplus of exportable cumin and its by-products, which would ultimately reduce cost of production, improve quality and increase income of millions of small and marginal farmers of the Western dry region.

Technology for Sustainable Production of IPM Cumin

Nurturing the crop plants for yield enhancement and quality optimization of the produce is the key to achieving system sustenance. The need is to optimize and tune the net inputs and outputs to match the social requirements and export quality standards, thereby accruing a sizable economic reward. The food system approach is appropriately suited for cumin which is highly susceptible to biotic and abiotic factors, and it also responds very well to physical, chemical, soil and environmental inputs. Therefore, the food system approach components must be designed to support the crop during various stages of production including germination, growth, flowering and fruiting to overcome weather vagaries and ultimately succeed in the high-quality production. The key components of the food system approach for quality production of IPM cumin are elaborated below:

3.1 Environment and soil requirements

Cumin prefers a dry climate and thrives well in the 15°C – 25°C. Thus, moderately cool and warm habitat suits cumin resulting in better growth, yield and disease-free quality produce amenable to export. Increased humidity at the critical growth stage(s) is harmful to the crop. Also, severe winters, frosts, dews and rains of moderate intensity at flowering and maturity stages are not endurable by the crop. Thus, the aberrant weather makes it favorable for inoculation of pests and diseases, deteriorating quality and shattering-related problems.

Figure 6: Cumin cultivar at vegetative growth phase

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2021

Cumin can noticeably be cultivated in a wide range of soil from sandy to clay loam, provided there is no water logging situation at all. The soil must be well-tilled and must retain sufficient moisture for optimum seedlings emergence. The soil must preferably be neutral but also cumin can have tolerance for slight alkalinity ranging from pH 7.0–8.0. Moreover, cumin should not be cultivated repeatedly on the same field for more than 2–3 years.

Figure 7: Cumin at reproductive phase

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2022

3.2 Time of sowing

Moderately cool and dry climate ranging from 15°C – 25°C is favorable for cumin cultivation. Atmospheric humidity during the flowering and seed setting stage is harmful, so is the frequent precipitation during the flowering, early fruit setting and maturity stage. The planting must be adjusted in such a way that the flowering stage does not coincide with high humidity. The most suitable time for sowing is between 15-30 November for Rajasthan. Environmental factors are highly congenial for the infestation of pests and diseases in cumin like aphids, Fusarium wilt, Alternaria blight and powdery mildew infestation. Frost and dew during the flowering and early fruit setting stage can cause significant injury and considerable losses to cumin. Therefore, the planting of the crop prior or later to the optimum time may lead to deteriorated quality and heavy yield penalty.

3.3 Selection of variety, seed rate and soil treatment

There are several varieties of cumin that have been released for cultivation in different areas including the micro agro-climatic regions of the Western dry region. However, Gujarat cumin-4, popularly known as GC-4 is the most popular variety for cultivation of cumin in Rajasthan as shown in Figure 8. As per the recommendation of ICAR-NRCSS, GC-4 was released in 2006 and is a Fusarium wilt resistant variety, which can yield an average of 875 kg per hectare in optimal production conditions.

Figure 8: GC-4 cumin variety in full bloom in 'CAZRI crop cafeteria', 2021

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2021

For the desired crop production, the optimum plant stand is required for which appropriate seed rate is 12 to 15 kg per hectare for broadcasting and 4-5 kg per hectare for line sowing. The sowing at 30×50 cm spacing with 1.0-1.5cm depth must be practiced for better germination. Usually, the cumin seedling emerges in 10-12 days from the days of sowing (DAS). However, delayed and depressed seed germination is a common problem in cumin. Therefore, pre-soaking cumin seeds in water for 4-6 hours followed by surface shade drying prior to seed treatment and sowing helps to hasten germination and optimal plant population.

Figure 9: Sprinkler irrigation post-sowing in cumin field

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2021

The emergence of seedling is crucial for cumin and thus adequate moisture must be maintained from the seed sowing to germination. It is advisable to ensure light irrigation at an interval of 5 to 7 days post-planting for uniform germination. Soil must also be applied with 2.5–3.0 kg *Trichoderma viride* regenerated in 100 kg compost at last ploughing of the soil. For low-cost inputs, a complex of 600 gm *Azotobacter* with 600 gm PSB must be applied in the soil before sowing of seeds. Generally, it is recommended to apply 10-12 tons FYM per hectare or 5 tons vermicompost to be applied for soil amendments. Additionally, a basal dose of 15:15:00 kg N:P:K per hectare at the time of sowing and 15 kg nitrogen per hectare at 30 days after sowing (DAS) to be applied. In total, cumin requires 4 sprinkler irrigations at crucial stages of vegetative growth.

3.4 Crop geometry and plant canopy

The soil must be tilled properly to ensure easy emergence of cumin seeds. Additionally, the crop must be sown in line by machine sowing to achieve uniform crop geometry and better intercultural operation. Inter and intra-line spacing must be maintained at 30×10 cm respectively. Seeds must not be sown at depth more than 1.0-1.5 cm and must be covered with a thin moist sand layer. The Biotech Kisan Hub has introduced the line sowing method as a part of a demonstration in village Budi Arjunpura, Nagaur District in two consecutive years 2021- 22 and 2022-23. Using conventional multipurpose seed drill machines, the Biotech Kisan Hub standardized practices of sowing seeds with seed drill while ensuring seed depth at 1-1.5cm and row-to-row distance at 25 cm (Figure 10).

Figure 10: Line sowing of cumin GC-4 variety in demo plot of Biotech Kisan Hub

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2022

3.5 Improved varieties

For achieving maximum yield with economically viable efforts and farm inputs, it is important to select suitable cumin varieties for different agro climatic regions as per the recommendation. A comprehensive list of approved cumin varieties is tabulated with key characteristics in table 2.

Table 2: Major characteristics of approved cumin varieties

S.No.	Cultivar	Growth period (days)	Developed at	Grain yield potential (q/ha)	Specific trait	Remarks
1.	GC-4	108-110	Spice Research Centre (SDAU) Jagudan, Gujarat	8.0-9.0	Showing field tolerance to wilt, bold shining seeds	Latest and best cultivar at the national level
2.	GC-3	100-102	Spice Research Centre (SDAU) Jagudan, Gujarat	6.5-7.0	Showing tolerance to wilt disease	Essential oil content 3.5%
3.	GC-2	100-102	Spice Research Centre (SDAU) Jagudan, Gujarat	6.5-7.0	Attractive grain, bushy, profuse branching	-
4.	GC-1	105-110	Spice Research Centre (SDAU) Jagudan, Gujarat	6.0-6.5	Showing shattering and lodging resistance, pink flower, bold brown seeds, wilt resistance	-
5.	RZ-345	120-130	SKN College Jobner	6.5-7.0	Bold attractive seeds	Higher volatile oil content
6.	RZ-223	125-130	SKN College Jobner	5.5-6.0	3.23% oil content	-
7.	RZ209	140-145	SKN College Jobner	6.0-6.5	Tolerant to wilt	-
8.	RZ-19	120-140	SKN College Jobner	4.5-5.5	Erect growth, pink flower, bold pubescent grains	Oldest variety

Source: Analyzed by South Asia Biotechnology Centre from different cumin resources of SKNAU, NRCSS and SDAU, 2024

3.6 Crop rotation

It is advisable not to repeatedly grow cumin on the same field for more than 2–3 years and must adopt crop rotation methods to optimize quality and yield. Cumin is not suitable for mixing and intercropping, and therefore must be avoided. Crop rotation is crucial for cumin growth, therefore, for successful yield and production, farmers are advised to follow recommended crop rotation with *dhaincha* & cumin; *dhaincha*, cumin and green gram; maize, cumin and summer green gram. Moreover, farmers must exercise precaution to grow mustard and wheat in the vicinity of cumin as they also harbor common pathogens such as *Alternaria* blight and Aphids pest.

3.7 Irrigation management

Cumin requires adequate moisture supply from planting to maturity period. After planting of seeds, two irrigations are mandatory for smooth and homogenous emergence of seedlings. First light irrigation must be applied immediately after sowing to avoid displacement of seeds and the second irrigation after 5–10 days must be ensured. Thereafter, 4 to 5 sprinkler irrigations at the intervals of 10-12 days are required.

3.8 Nutrient management

Fertilizer should be applied on the basis of the report of the soil test and recommended dose of fertilizers (RDF). Generally, a basal dose of 15:15 kg Nitrogen and Phosphorous per hectare should be applied at the time of sowing. The recommended dose of N and P in the ratio of 1:1 gives a higher yield of a good quality product. Generally, 10-12 tons FYM per hectare or 5 tons vermicompost to be applied for soil amendments. Additionally, 15 kg nitrogen per hectare at 30 days after sowing (DAS) should be applied to hasten vegetative growth.

3.9 Weeding and intercultural operations

Cumin grows slowly at the initial stage as it is characterized by its short stature and is severely subjected to weeds resembling cumin such as jeeri. Bathua (*Chenopodium album*), Khartua (*Chenopodium murale*), Piaji (*Asphodellus tenifolius*), Jeeri (*Plantago pumila*; wild), *Heliotropium ellipticum*, pilisanjee (*Melilotus indica*) are the common weeds for seed spices found along with the crop. Jeeri is a very harmful weed, the seeds of which bear a close resemblance to cumin seeds. Therefore, the Jeeri weed should be removed before the flowering stage of cumin in order to avoid contamination of the latter with jeeri seeds. In case cumin seeds get contaminated with jeeri seeds, it would fetch poor prices in the market. Effective from April 2023, the European Union has substantially reduced the maximum residue level (MRL) of Pyrrolizidine alkaloids (PAs), a plant toxin commonly found in jeeri weed to 400 µg per kg or 400 ppb or 400 parts per billion for dried herbs and cumin seeds, and 300 µg per kg for mixtures where the proportion of the ingredients is not known. Therefore, it is becoming increasingly important to effectively manage jeeri weeds in cumin crops. In addition, farmers are advised to remove leftover weeds before shedding of the seeds to prevent further spread of weeds. Therefore, weed infestation should be effectively managed by pre-planting spray of Pendimethalin 30% EC @3.25 liter per hectare followed by 2-3 weeding and hoping operations are necessary for better weed control in cumin.

Plant Protection and Crop Health Management

Cumin harbors insect pests and diseases from the very early vegetative stages to crop maturity. Sucking pests, especially aphids and thrips cause maximum yield damage and significantly increase cost of production. The physical quality of seeds by aphids-infested plants deteriorates due to the shriveled seed size and deposition of honeydew secreted by the pests, thereby reducing the essential oil in the seeds.

4.1 Pre planting measures

Moderately cool and dry climate ranging between 15°C – 25°C. is suitable for cumin cultivation. However, high humidity and frequent precipitation during the flowering stage poses disease risk to the crop. Invariably, the crop suffers from *Alternaria* blight, *Fusarium* wilt and bacterial diseases, therefore pre-planting treatments and inputs are crucial and mandatory for assured cumin production.

Seed and soil treatments: Treatment of seed with *Trichoderma viride* @ 4gm per kg seed, soil solarization as summer ploughing and application of neem cake @ 200gm per kg. For IPM and organic production of cumin, treating soil with *Azotobacter* @10g per kg & with 5 tons per hectare goat manure is recommended. Application of 10-15 tons FYM or 5 tons of vermin-compost per hectare at the time of field preparation may be implemented. For better seed germination, adequate soil moisture is required at the time of sowing.

4.2 Post planting protection

Cumin harbors insect pests from the very early vegetative stages to crop maturity. Being a sensitive crop at the time of vegetative and flowering stage of the crop cycle, cumin should be critically examined and monitored to check the infestation of pests and diseases. Proper monitoring and surveillance of pests and diseases infestation should be adopted. The mass trapping using yellow and blue sticky traps should be installed as a post planting measure to monitor the intensity of infestation and observation of infested plants in necessary with the regular field checks.

4.3 Pest management:

Monitoring sucking pest: Farmers are advised to install 25 yellow and 25 blue sticky traps for mass trapping and regularly monitoring of aphid and thrips pest incidences in order to determine the economic threshold level (ETL) based application of biocontrol such as botanical and microbials and in case the incidence is severe, the application of approved insecticides must be applied (Figure 11).

Figure 11: Installation of sticky traps to prevent pest infestation

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2022

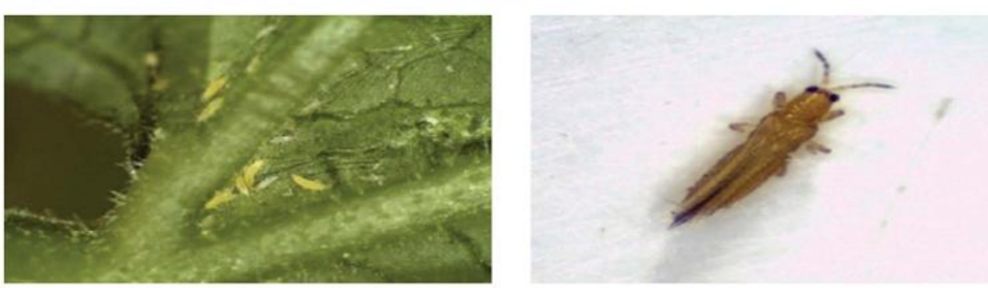
Aphids: Aphids damage the crop by sucking the plant sap of the leaves and umbels. When the aphid infestation occurs at the flowering and fruit stage, the fruits are either not formed or they are shriveled and of poor quality. Five species of aphids infest the cumin crop; the most pervasive ones are *Myzus persicae* and *Aphis gossypii,* reported from Rajasthan and Gujarat. *Myzus persicae* is green in colour and develops early on the crop during January, followed by colonization of black aphids (*Aphis gossypii*). The different stages of aphid attacking the cumin crop shown in figure 12.

Figure 12: Different stages of aphid infestation in cumin

Source: ICAR-NRCSS, 2023

Thrips: Thrips population develop on cumin just after germination and last up to the flowering stage. Both adults and nymphs, as shown in figure 13, congregate on the leaf sheath or in the flowers and feed on the plant sap by lacerating the leaf tissues, causing drying of the leaves and umbels. There are seven species of thrips that attack cumin crops, but the most prominent are *Frankliniella schultzei*, *Scirtothrips oligochaetus* and *Thrips tabaci*.

Figure 13: Moth and larva of thrips in cumin



Source: ICAR-NRCSS, 2023

GAP in the management of aphids and thrips: Steps to manage the infestation of aphids and thrips in production of IPM cumin are as follows:

- Keep the crop free from weeds during the entire growth period
- Strictly follow the recommended time of sowing i.e. first or second week of November.
- Apply the recommended dose of nitrogenous fertilizers as excess nitrogen supports pest attacks.
- Install yellow or blue sticky traps at the early vegetative stage.
- Regularly monitor the population and intensity of insect pests, predators and parasitoids etc.
- Apply botanicals such as NSKE 5.0%, neem oil 2.0%, *Azadirachtin* 10,000 ppm at the rate of 2.0 ml per liter and bio-pesticides like *Lecanicillium lecanii* 1x108 colony-forming units CFUs/g 5.0 g per liter of water as foliar spray on the crops.
- In case of severe infestation, apply insecticides as per the approval and label of the CIBRC in the right dose & right time under right condition to prevent yield losses as per table 3.
- Ensure judicious application of insecticide to protect and conserve Honeybees (*Apis florea*), which are a major source of pollination for cumin.

Table 3: Approved insecticides for management of insect-pests in cumin

Insecticides	Name of pests	Dosage/ha		
		Active ingredients (kg)	Formulation (g/ml)	Dilution in water (liters)
Tolfenpyrad 15% EC	Aphids, Thrips	150	1000	500
Carbosulfan 25% EC	Aphids, Thrips	312.5	1250	500
Thiamethoxam 25% WG	Aphids	25	100	500

Source: CIBRC, 2024; Analyzed by South Asia Biotechnology Centre, 2024

4.4 Disease management

Cumin wilt (*Fusarium oxysporum* f. sp. *cumini*): *Fusarium* wilt is common when the crop is about one month old. At this stage, the damage is more severe than the disease appearing in the later stages. Leaves of the infected plant droop, turn yellow and ultimately wilt and dry up (Figure 14). Subsequently, the whole plant may die. The diseased plants can easily be uprooted, and their roots exhibit browning of the vascular region when split open. The fruiting of cumin may not occur when the wilting takes place at the reproductive stage. The diseased plants usually produce small, thin and shriveled seeds resulting in deterioration of quality and significant yield loss.

Figure 14: Wilt infected cumin in CAZRI demonstration plot

Source: Central Arid Zone Research Institute, 2024

Management of cumin wilt: Steps to manage the infestation of *Fusarium* wilt in production of IPM cumin are as follows:

- Avoid monoculture and practice crop rotation.
- Grow GC-4 and RZ-223 cumin varieties tolerant to *Fusarium* wilt.
- Practice summer ploughing which may help in reducing weeds, pests and disease.
- Application of neem cakes at 5 tons per hectare, castor cake and poultry manure before sowing have been found to reduce wilt.
- Organic amendments of soil with mustard cake (1%) and incorporation of mustard residues in soil have been seen to reduce *Fusarium* propagules.
- Bio-priming with antagonistic microflora on wilt incidence was found to be effective in tackling the disease.
- Foliar application and drenching of roots with *Trichoderma viride* and *Pseudomonas fluorescens* at 6 ml per liter, respectively.
- In case of heavy incidence, farmers are advised to apply only CIBRC approved fungicides in the right dose & right time under the right condition (Table 4).

Moreover, the research efforts to control cumin wilt conducted under the All India Coordinated Research Project on Spices revealed that the wilt disease can be controlled by adopting the following practices:

- Sowing of healthy and disease-free seed which are tolerant to *Fusarium* wilt.
- Adoption of three years crop rotation with clusterbean followed by cumin; clusterbean with wheat and clusterbean followed by mustard.
- Use of *Trichoderma viride* for seed treatment at the rate of 0.4 g per kg seeds or solarisation of plots during summer.
- Summer ploughing in the early stage of crop growth.
- Application of neem cake at the rate of 200 g per kg of seed.

Management of cumin in IPM and organic farming: Application of mustard residue (2.5 tons/ha) together with mustard cake (0.5 tons/ha) and neem cake (0.5 tons/ha) as soil amendments, with one irrigation during hot summers. Application of *Trichoderma viride* or *Aspergillus versicolar* as seed treatment at the rate of 10 gm per kg seed and soil application at the rate of 2.5 kg per ha mixed with 50 kg of FYM at the time of sowing. Soil solarization in combination with oil cakes has also been found to be highly effective.
***Alternaria* blight (*Alternaria burnsii*):** Cumin crop is susceptible to *Alternaria* blight at the flowering and fruiting stage. The blight disease appears as a small isolated whitish necrotic area on the leaf and stem (Figure 15). The minimum, optimum and maximum temperature requirements for the growth of *Alternaria burnsii* are 4.5°C, 26°C to 30°C and 35°C, respectively.

Figure 15: Alternaria Blight infected cumin

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2023

Management of *Alternaria* blight: Steps to manage the infestation of *Alternaria* blight in production of IPM cumin are as follows:

- Aerial spray of 1% *Bordeaux* mixture.
- Crop rotation with non-host crops, deep ploughing and summer fallowing have proved effective in reducing the disease.
- No effective biocontrol measures of *Alternaria* blight.
- In case of heavy incidence, farmers are advised to spray CIBRC approved fungicides (Table 4) such as *Tebuconazole* 50% & *Trifloxystrobin* @ 25% or 0.6 g per liter or *Zineb* 68% & *Hexaconazole* @ 4 % @ 2 g per liter or *Metiram* 55% & *Pyraclostrobin* @ 3.5 g per liter etc.

Powdery mildew (*Erysiphae polygoni*): The powdery mildew disease usually appears late in the season by the end of February or March, reaching maximum intensity at the time of flowering and seed formation. The fungus perpetuates as a dormant mycelium in plant debris in the soil or on the seed. Infected seeds would germinate to form infected seedlings. As the infected seedlings grow, the fungal mycelial also grows and infects various parts of the plant including the flower. The mycelial growth on the flower results in the development of poor quality seeds which, in turn, reduces the yield of the plant. When the disease is severe, the entire affected field appears to be dusted with white powder.

Management of Powdery mildew: Steps to manage the infestation of Powdery mildew in production of IPM cumin are as follows:

- Application of 2.0% solution of wettable sulphur in 500 litre water per hectare with repeat of spraying after 15-20 days.
- Dusting plants with 300 mesh sulphur dust at the rate of 25 kg per hectare as soon as the symptoms are noticed.
- Infected plants show reductions in chlorophyll, total soluble sugar and crude protein. Application of tetracycline hydrochloride controls the disease.

Table 4: List of CIBRC approved fungicides for management of pathogens in cumin

Fungicides	Name of Pathogen	Dosage/ha		
		Active Ingredient (kg)	Formulation (kg/l)	Dilution in water (l)
Azoxystrobin 23% SC	Blight, Powdery mildew	0.115	0.50	500
Difenoconazole 25% EC	Blight, Powdery mildew	0.0125% or 0.012 kg/ 100 l water	0.05% or 50 ml/100 l water	500
Mancozeb 75% WP	Blight	1.125-1.5	1.5-2	500
Picoxystrobin 22.52% w/w SC	Blight	0.10	0.40	500

Fungicides	Name of Pathogen	Dosage/ha		
		Active Ingredient (kg)	Formulation (kg/l)	Dilution in water (l)
Tebuconazole 25% WG	*Alternaria* blight, Powdery mildew	0.001	0.007	500
Metiram 55% +	*Alternaria* blight,	0.9-1.05	1.50-1.75	500
Pyraclostrobin 5% WG	Powdery mildew			
Pyraclostrobin 0.13 kg/ l + Epoxiconazole 0.05 kg/l SE	*Alternaria* blight	0.137	0.75	500
Sulphur 40% SC	Powdery mildew	0.0014	3.50	1000
Sulphur 80% WDG	Powdery mildew	1.50-2.00	1.875-2.50	750-1000
Sulphur 85% DP	Powdery mildew	12.75-17	15-20	
Azoxystrobin 23% SC	Blight, Powdery mildew	0.115	0.50	500
Difenoconazole 25% EC	Blight, Powdery mildew	0.0125% or 0.012 kg/ 100 l water	0.05% or 50 ml/ 100 l water	500

Source: Analyzed from minutes of CIBRC by South Asia Biotechnology Centre, 2024

New & emerging problems in cumin

Reddening: Reddening is a new problem reported in all cumin growing areas of Western dry region. The research studies suggested it is a physiological and environmental problem that can occur at initial crop growth up to maturity (Figure 16).

Figure 16: Reddening of cumin

Figure 17: Yellowing of cumin

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2023

Yellowing: Cumin yellowing is a new viral disease reported in cumin growing areas of Western dry region. The virus associated with it has been identified as Vanilla distortion mosaic virus (Potyvirus) (Figure 17).

Root decaying: This disease, showing root decaying symptoms caused by nematodes *Hoplolaimus* spp. and *Tylenchorhynchus* spp. in coriander, fennel and nigella, has also been reported in cumin in Western dry region.

Conservation of predators, parasitoids and pollinators

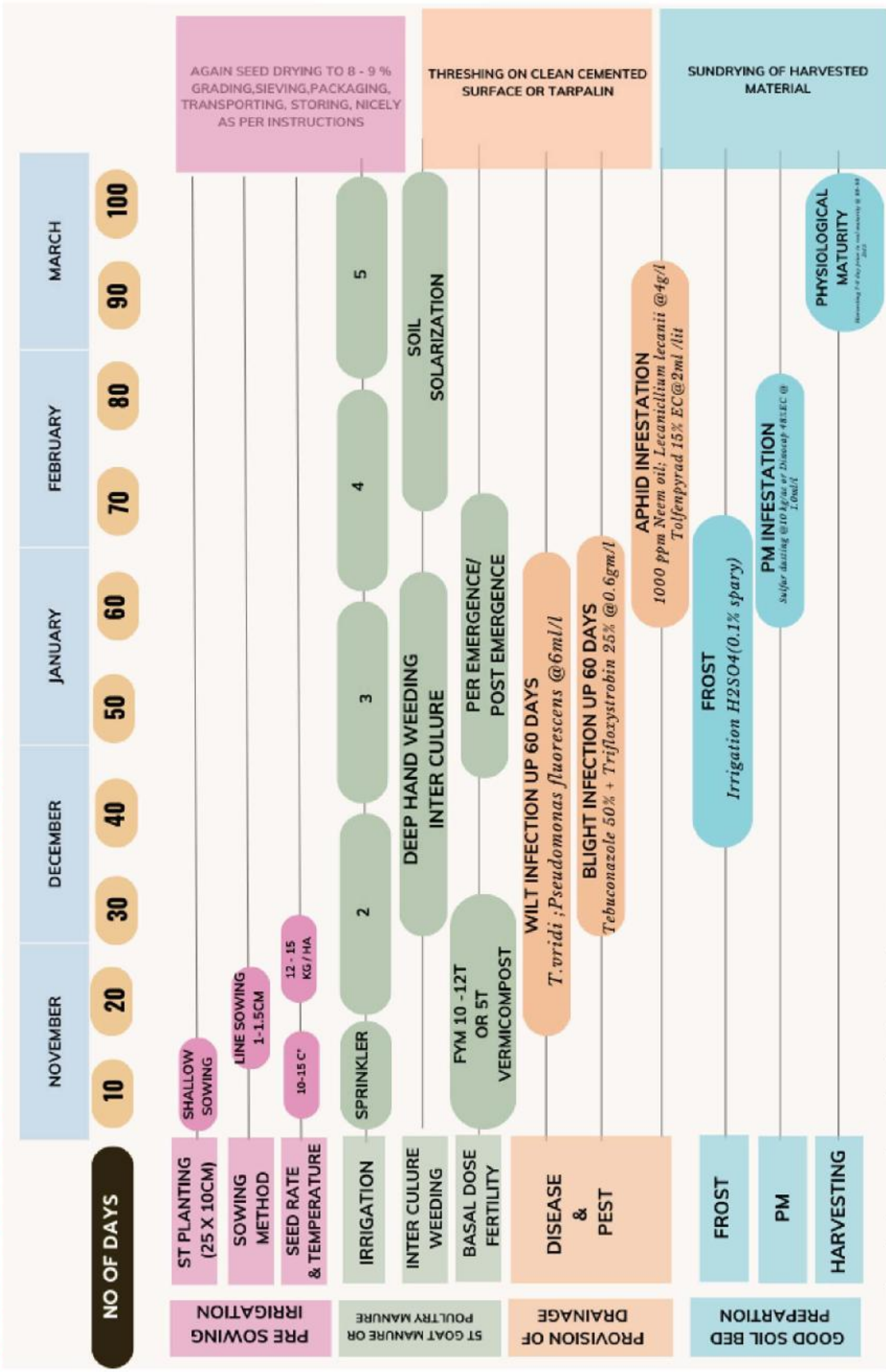
Honey bees (*Apis florea*) aid in the pollination of cumin. The natural pollinator population can be conserved preferably by adoption of IPM based package of practices focusing on timely monitoring, ETL based application of crop protection measures, use of sticky traps and prioritization of biocontrol-based practices. Abundance of natural enemies such as *Coccinella Adult, Syrphid fly, Chrysoperla* and Parasitoids *Aphidius sp.* are some of the examples of natural bounty for the management of insect-pests in cumin production systems.

4.5 Frost management

Cumin is a delicate seed spice, sensitive to cold shocks and chilling injuries at the initial flowering and seed formation stages. In the situation of a sudden drop in temperature, clear sky and low wind, the likelihood of cold shocks in the form of frost is expected. In such situations, crops must be irrigated and smoke must be developed over the crop to protect against cold stress. Additionally, the use of sulfuric acid spray @ 0.1% during cloudy days is advocated.

Figure 18 shows the essential pre-planting and post-planting components for improved grain yield, irrigation schedule and the critical stages of disease infestation, frost problem and appropriate stage of crop harvest along with recommended fungicides. Moreover, the step-by-step best practices for improved yield and quality of cumin is enumerated in annexure 1.

Figure 18: Practices for optimization of yield and quality of cumin



Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2024

Harvest, Post Harvest Management and Processing

5.1 Harvesting

The harvesting of cumin must be completed in a crucial and time bound manner to avoid shattering. Generally, the physiological maturity such as drying of umbels is better than the drying of the whole plant. Plants must be harvested as soon as the crop attains physiological maturity to ensure higher grain yield and quality of the produce. Delayed harvesting and over drying of the harvested crop may cause loss of volatile oil and hence deteriorate quality. Matured cumin must be harvested during the morning or late evening to avoid losses due to shattering.

5.2 Processing and cleaning

Processing consists of drying, cleaning, sorting and grading. Cleaning, sorting and grading is to be done with the help of different machines like spiral separator, magnetic seed separator, electronic colour sorter, destoner and rotary knife etc. Commercially, vacuum or gravity separator is used for cleaning and grading of cumin seeds. Threshing is carried out by power thresher or by hands on a clean concrete or tarpaulin surface. Farmers can harvest grain yield to the tune of 7-8 quintal per hectare with proper harvesting and post-harvest management.

Figure 19: Harvesting and threshing of cumin in Biotech Kisan demo plot

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2022

5.3 Storage

Well-packed cumin seeds should be stored in a ventilated dry and cool place. Graded and cleaned grains must be packed at a moisture level of 7% at relative humidity of 40%. The moisture proof packaging should be done in gunny bags lined with polythene and must be stored on the plank or raised platform to protect against contamination. Sealed steel containers must be used to save stored material against storage bruchids or other pests. Stored material should be periodically checked by authorized persons.

5.4 National and global quality standards for cumin

Cumin possesses significant importance as a domestic and export commodity. The domestic consumption of cumin seeds is estimated at 3,50,000 tons. Approximately one third of India's production is exported. Setting quality and safety standards for cumin is of paramount importance for facilitating international trade and protecting farmer and consumer interests.

India's cumin face major export hurdles due to high levels of pesticide residue. With the implementation of Biotech Kisan Hub project and increased participation of key stakeholders in the cumin production system has led to widespread adoption of integrated pest management (IPM) programs resulting in improvement in quality of cumin. IPM programs are mostly being implemented in the geography of Biotech Kisan Hub of Western dry region covering districts of Barmer, Jaisalmer, Nagaur, Jodhpur, Pali, Jalore-Sanchore and Ajmer.

Allergen and plant toxin free production, food safety certification combined with sterilization and reliable food safety tests have attracted importers to cumin produce in the Western dry region of Rajasthan. Moreover, the Spice Board of India in collaboration with DBT Biotech Kisan Hub has been facilitating the quality production and evaluation of spices and spice products before their export. Consequently, the systematic quality control and safety monitoring have become a guiding norm for the export of IPM cumin from India.

5.5 Pyrrolizidine alkaloids (PAs) as contaminants in cumin

The pyrrolizidine alkaloids (PAs) are a group of compounds that naturally occur in plants, such as *Heliotropium, Crotalaria, Senecio, Tricltodesma, Symphytum, Echium,* and other genera of the *Boraginaceae* family. Moreover, the PAs-containing plants grow as weeds among cumin and the seeds are known to contaminate the harvest. The predominant types of Pyrrolizidine alkaloids (PAs) and Pyrrolizidine alkaloids N-oxides (PANOs) found in cumin belong to the *Heliotropium* genus of the *Boraginaceae* family. Consumption of such contaminants leads to toxic diseases and may affect human health. Effective from April 2023, the European Commission Regulation (ECR) No 1881/2006 (2) has prescribed maximum levels for PAs and PANOs occurring as contaminants in seed spices, particularly for cumin seeds at 400µg per kg, which may become a major bottleneck for cumin export in the future. Farmers are advised to take preemptive measures in the production system such as application of weedicides and proper weeding of PA-producing flora such as jeeri weed in the cumin field to reduce PAs contamination in cumin.

5.6 ETO and maximum limits

Ethylene oxide known as ETO, a biocide, is commonly used in healthcare and food industries for sterilization purposes, which has recently been reported in exported cumin. ETO is considered as a hazardous air pollutant by the US EPA as exposure to its high levels is harmful. Ethylene oxide (ETO) treatment as a pesticide has been banned by the European Commission under Regulation (EC)

1107/2009 covering both materials treated within and outside of the EU. The European Commission has specified the level of ETO at 0.1 mg per kg as the analytical limit of quantification (LOQ) which is now the permissible maximum limit for ETO in food and feed additives such as processed cumin. The Spices Board of India in consultation with the EU has suggested measures to the processors and exporters of cumin to control and manage ETO in cumin and other spices.

5.7 Commercial standards for international organization

At the International level, the Codex Alimentarius Commission (CAC) periodically sets guidelines for fixation of maximum residue levels (MRLs) and prescribes codes of practice to ensure safety, quality and fairness of international food trades. The MRL guidelines are based on the recommendations of FAO-WHO Joint Meeting on Pesticide Residues (JMPR). In India, the standards for cumin, both whole and powder are defined under Regulation 2.9.8 of FSSAI's Food Products Standards & Food Additives regulations, 2011, according to which cumin shall have characteristic color, aroma and flavor. It shall be free from live insects, any foreign odor or flavor and mustiness, also free from added color and harmful substances. The pesticide MRLs vary from country to country however, the average permitted MRL value by FSSAI and other importing countries is around 0.01 ppm which is updated regularly. In India, the quality of food and food safety are enforced through certifications which are followed by food industry in order to assure food quality, such as, Agriculture Grading and Marketing (AGMARK), a certification mark employed on agricultural products in India, assuring that they conform to a set of standards approved by the government of India. Similarly, the Hazard Analysis Critical Control Point (HACCP) system identifies specific food hazards and measures for their control to ensure food safety. The application of such systems can assist inspection by regulatory authorities and promote international trade by increasing assurance in food safety.

The major governing organization of the European spice industry is European Spice Association (ESA), yet, most European markets follow the cleanliness specifications defined by the American Spice Trade Association (ASTA), which delineates the maximum levels for the presence of dead insects, excreta, molds, and other foreign matter (Annexure 2), however, the ESA does not permit the presence of any foreign substance greater than 2 mm in diameter, whereas the limit of extraneous matter is set to 1% by weight.

Cumin oil standards: Cumin oil must be colorless or with light yellow color, specific density 0.905-0.925 at 25 , optical rotation +3 to +8 at 25 , solubility (80% ethanol) at 8 volumes, moisture from 11-12%, aldehydes (cumin aldehyde) from 40-52%. The microbiological factors that define the nutritional quality of cumin (whole seed and ground) have been discussed in annexure 2.

Although food safety certification is not obligatory under European legislation, it has become a must for almost all European food importers. The European Commission Regulation sets maximum levels for certain contaminants in food products. Frequently updated, EC regulation sets limits for general foodstuffs, in addition to some specific contaminant limits for specific products. The European Union Regulation 2021/2246 dated Feb, 2022 for export of spices to EU has made food safety certification mandatory to permit entry of the consignments in order to reduce the risk of contamination of ethylene oxide (ETO), *Salmonella* and filth in the imported food articles. The essential parameters and other requirements to comply with maximum residue limits permitted by the Spice Board of India for the export of cumin to the international market have been enlisted in annexure 2.

5.8 Value addition in cumin

Cumin is known to have enormous commercial value for whole seed, powder and and its by-products in both domestic and export markets. Cumin seeds are mainly used as a condiment in cooking such as in all mixed spices, curry powder, for flavoring vegetables, pickles, soups, sausages, cheese, and for seasoning breads, cakes and biscuits.

The aromatic oil of cumin seeds is also used for flavoring curries, liquor and cordials, and is also used by perfumery units. India exports almost 5 tons of cumin oil per year which is almost 17% of the world trade. Cumin is also used in many ayurvedic and veterinary medicines as a carminative, stomachic and astringent.

5.9 Minimization of pesticide residue

The use of pesticides has become an important part of modern farming practices both in field and in storage, to reduce crop losses. In order to determine food safety, the regulatory agencies across the countries set MRL for pesticides in food products (Annexure 2). Food products containing pesticide residue above the prescribed limit (MRL) are rejected at the international market. In India, the MRLs of pesticides in food products are determined by the Food Safety and Standard Authority of India (FSSAI) under the Ministry of Health and Family Welfare on the basis of field trials and risk analysis parameters including toxicological data and dietary exposure for food safety. Table 3 and 4 enlists the approved insecticides and fungicides to be used for managing the pests and diseases in cumin in India. In addition, table 5 enlists the stranded for spice in microbial contamination.

Table 5: Standard for spices in microbial contamination

S. No.	Microorganism	Limit
1.	*E. coli*	≤ 3/ g
2.	*Salmonella*	Absent in (at least) 25 gm
3.	Aerobic plate count	≤ 50,000/ gm
4.	Yeast and mold	≤ 100/ gm
5.	Aflatoxin	20 µg/ kg

Role of Biotech Kisan Hub in Advancing IPM Cumin Farming System

India shares a commanding position in the global spice trade with respect to volume and value. The value-added seed spices products as well as the raw material contribute roughly 50-60% of the total global spices demand. In India, Rajasthan and Gujarat are widely known as the major cumin producing states covering vast geographical areas of Western dry region of Rajasthan including districts of Barmer, Jaisalmer, Jalore-Sanchore, Jodhpur, Nagaur and Pali. These districts grow and produce large quantities of cumin which suffer from pesticide residue and other quality parameters such as dust mixture, diseased, moistened, unripe seeds and other physical contaminants. The pesticide residue and impurities in cumin production have become key obstacles in export due to quality standards set by the importing countries. Moreover, the productivity of cumin is abysmally low due to poor germination and sub-optimal plant density. To address these challenges and advance IPM cumin farming system, the Biotech Kisan Hub for Western dry region supported by the Department of Biotechnology (DBT) of the Government of India was established at the South Asia Biotechnology Centre (SABC), Jodhpur in collaboration with the National Research Centre on Seed Spices (ICAR-NRCSS), Ajmer.

6.1 Biotech Kisan Hub for western dry region

The Biotech Kisan Hub for Western dry region was established at Jodhpur, which has carried out activities in major cumin growing districts of Rajasthan from 2020 to 2023. The hub aimed at enhancing the quality of production, processing, value chain development and export of cumin. Besides, the hub laid out large scale demonstrations to showcase best package of practices (PoP) to the farmers and also strengthen the export value chain of cumin (Figure 20). The hub in collaboration with ICAR-NRCSS has helped cumin farmers to learn and adopt best production practices, technically viable solutions and sustainable know-how to significantly improve the quality of cumin. Based on the analytical testing, the hub referred to pesticide residue free cumin as IPM cumin and popularized 'IPM branded cumin' in the domestic market. Moreover, the hub has generated a wide range of technical resources, demonstrated good agricultural practices (GAP) and integrated pest management (IPM) practices in farmers' field, organized on-farm training programs, conducted kisan mela and established a value chain system to bridge the knowledge gap (Figure 21). In summary, the hub facilitated transfer of technologies developed by ICAR-NRCSS with reference to soil and nutrient management, integrated pests and diseases management through large scale calibrated field demonstrations linking farmers to quality processing and exporter to enhance farmers income and livelihood.

Figure 20. Engagement with key stakeholders in cumin value chain development

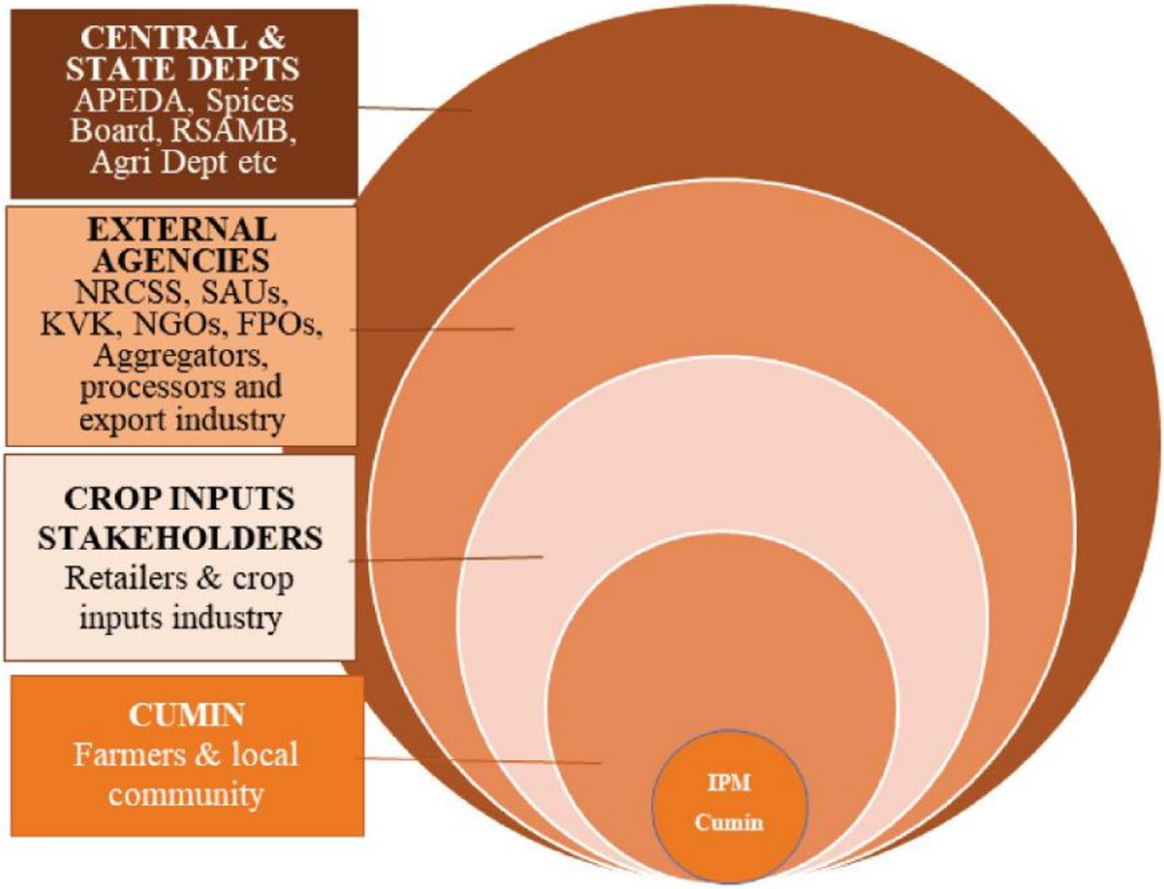


Figure 21: a). The Biotech Kisan Hub for Western Dry Region. **b).** GAP practices chart for IPM cumin produced under Biotech Kisan Hub **c).** Farmers training program **d-e-f).** Tinkering laboratory for soil and water testing at Biotech Kisan Hub for Western Dry Region, Jodhpur

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2022

6.2 Farmers mobilization and community participation

The Biotech kisan hub has identified progressive farmers to implement the field demonstration of GAP and IPM, and mobilized them for on-the-farm learnings and adoption of technology for area-wide socio-economic impact. In nutshell, the hub successfully laid out 47 field demonstrations that showcased GAP and IPM protocols in selected farmers' fields approachable to neighboring farm communities for the seeing-is-believing method of technology adoption. To all the participating farmers, the hub project team distributed bio-kits comprising of high-quality seeds, biologicals for seed treatment, biofertilizers, microbials and bio-pesticides, shared the package of practices (POPs) curated in local language, and provided a series of technological interventions relevant to every aspect of cumin production (Figure 21 a-c). Pre-sowing group discussion with identified farmers in their field motivated farmers to implement intervention in the right spirit. The hub has carried out soil and water testing of each demonstration field to assess the soil fertility for proper nutrient management. The hub has worked closely with farmers throughout the season from sowing to harvesting. Active engagement of the biotech kisan team enabled farmers to adopt the GAP and IPM package of practices and established a value chain system. Moreover, the hub has assisted farmers to use multi-crop threshing machines to thresh and pre-process harvested cumin for better price realization. The hub team has also distributed tarpaulin sheets at free of cost to cumin farmers in collaboration with the Spices Board of India to promote proper drying and maintain quality of harvested cumin during the implementation of the project from 2020 to 2023.

In achieving project goals, the team has established strong linkages with key stakeholders like SAUs, KVKs, APEDA, the Spice Board of India, RSAMB, State agri departments, FPOs and other local voluntary organizations. The hub has implemented 47 field demonstrations on IPM cumin spread in intensive cumin growing districts of Barmer, Nagaur, Pali, Jodhpur, Sanchore and Jalore between 2020 to 2023. By the end of the project, around 4914 beneficiaries including men and women farmers have benefited from the activities of the Biotech Kisan Hub for Western dry region. Moreover, the hub also mobilized Farmers' Producers' Organizations such as Balaji FPO, Pali and Marwar FPO, Nagaur to aggregate cumin produce and has engaged multiple processors and exporters in training programs and procurement of IPM cumin.

6.3 GAP and IPM agriculture

The hub in collaboration with ICAR-NRCSS has also provided and translated the need-based technologies to the smallholder farmers as highlighted in annexure 1 on production and value chain development, gap analysis and key technical interventions including GAP and IPM, know-how and technology transfer and linking partners in the value chain system.

Insect-pests management: The hub has conducted field experiments, intensive on-farm training of farmers for effective management of insect-pests by installation of yellow and blue sticky traps in structured manner for the mass trapping and regular monitoring of aphids and thrips and undertaken control measures based on economic threshold level (ETL).

6.4 IPM based bio-kit distribution

The bio-kit including high quality GC-4 cumin seeds, bio-based seed treatment, growth regulators, bio-fertilizers, bio-pesticides including neem oil, botanicals & microbials and sticky traps were distributed to the farmers by the hub in the Western dry region supported by the Department of Biotechnology (Figure 21d-f).

6.5 INM based soil-water health

The hub has set up the state-of-the-art and functional tinkering laboratory at Jodhpur based field office to test soil and water samples to appropriately advise the farmers about integrated nutrient management (INM) practices.

Figure 22: Biotech Kisan Hub tinkering lab at South Asia Biotechnology Centre, Jodhpur

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2021

The tinkering laboratory has supported farmers engaged in IPM field demonstrations under the project (Figure 22). The soil and water samples were collected from different demonstration plots, processed and analyzed in the tinkering laboratory. The soil health cards were generated based on the test results and appropriate macro and micro-nutrient recommendations were provided to each of the concerned farmers. In addition, the tinkering laboratory also analyzed irrigation water to determine various water quality parameters to tackle brackish water (Annexure 3).

6.6 Pesticide residue analysis

During the project implementation, the hub in collaboration with Spices Board India and ICAR-NRCSS worked together to promote IPM based production systems and facilitated transfer of relevant technology. The hub has randomly collected samples of harvested cumin and tested them for pesticide residue from the NABL accredited laboratories. Cumin samples were collected by engaging 4 FPOs and 7 seed spices companies in the targeted areas. For instance, the clusters of Barmer, Jaisalmer, Jodhpur, Nagaur and Pali districts have emerged as an important region for producing pesticide residue-free IPM cumin.

6.7 PHI and percent moisture in grains

The pre harvest interval (PHI) is the minimum amount of time between the last application of a pesticide and when the crop can be harvested. The PHI is found on the pesticide label and complying with a PHI is a legal requirement. The hub through field demonstration has developed the skill of participating farmers to read and understand label claims particularly on PHI to ensure proper management of pesticide residue in cumin and other seed spices.

6.8 Field visits, survey and monitoring

The hub has organized a large number of farmers programs including 8 technical webinars with 1050 participants, 14 farmers' field day programs involving 2474 smallholder farmers and 7 scientific training programs involving 1390 with 57 field visits to monitor crops at different stages in demonstration fields. The objectives of field visits were to ensure that farmers imbibe knowledge about farm inputs and adopt best practices based on soil and water analysis. As a result, there was an area wide adoption of botanicals, microbials and biopesticides and proper management of pesticide residue for improved quality output. The key features of the 47 field demonstrations of IPM cumin focussed on:

6.8.1 Demonstration of yellow and blue sticky traps: Cumin is susceptible to pest infestation such as aphids, thrips and other sucking pests. The installation of yellow and blue sticky traps in a structured manner for the monitoring and mass trapping of aphids and thrips helped in substantial minimization of their population (Figure 11). The traps were installed in a specific pattern to determine the optimal number of traps required for the mass trapping of aphids and thrips at 25 yellow and 25 blue traps per acre. The sticky traps helped farmers to monitor crops on a real time basis, reduce pesticide sprays and significantly improved control measures of aphids and thrips.

6.8.2 Demonstration of neem oil and *Lecanicillium lecanii*: To overcome challenges of quality and food safety, farmers were educated to adopt the IPM based production system. The hub has reported a growing interest of farmers for production of IPM cumin since its establishment in 2020. Farmers were invited to adopt IPM cumin on large-scale through field demonstrations and on-site training programs ensuring increased use of botanicals and microbial biopesticides.

6.8.3 Biological seed treatment and seed replacement rate (SRR): A good quality GC-4 seed is critical for germination and plant growth. In demonstration programs, the farmers were given quality cumin seeds and trained to produce quality seeds from disease free plots for sowing in the subsequent seasons. Furthermore, farmers were trained and advised to treat seeds with *Trichoderma viride* or *Mycorrhiza* @10 gm per kg seed, which helped in control of soil-borne diseases. Seed treatment is crucial for healthy seedlings against soil and seed-borne diseases.

6.8.4 Application of *Trichoderma viride* with decomposed FYM: Appropriate field preparation practices like ploughing and harrowing and applying well-decomposed FYM @ 10 tons per hectare was recommended to the farmers. The incorporation of *Trichoderma viride* with FYM helped to control soil-borne pathogens and spores present in the soil in the demonstration fields.

6.8.5. Mahila kisan biotech fellowship: The hub awarded mahila kisan biotech fellowship to 6 progressive women farmers involved in the implementation of field activities in Jodhpur, Nagaur and Pali districts of Western Rajasthan. The mahila kisan biotech fellowship under the mission program on Biotech-Krishi Innovation Science Application Network of the Department of Biotechnology, Ministry of Science & Technology, Government of India provided fellowships and certificate to 6 women farmers for their active participation and significant contribution in promotion of activities of the hub in Western Rajasthan.

As part of Mahila kisan biotech fellowship, the progressive women farmer played a facilitative role in training programs, laboratory visits and field demonstrations, helped women farmers in the neighborhood about the importance of GAP and IPM and regular monitoring of demo farmer operations carried in their fields. Mahila kisan also participated in farmer meetings at demo units, interacted with media and amplified good agricultural practices among farmers (Figure 23).

Figure 23: Mahila kisan biotech fellow Ms Kavita Shivkiran with Biotech Kisan Hub team

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2022

6.9 Harvesting and post harvesting measures

The hub trained a large number of smallholding farmers at the site of field demonstrations to popularize GAP and IPM production, and create awareness of the scientific know-how of pre and post planting management, harvesting and post harvesting including storage practices. In order to achieve proper threshing, primary processing and to reduce wastage, the hub showcased and organized farm demonstrations of newly introduced thresher-cum-primary processors of cumin supplied by M/s Shri Ganesh Agricultural Works, Jodhpur (Figure 19).

6.10 Value chain partnership and downstream industry linkages

Linking farmers to industry was one of the major objectives of the Biotech Kisan Hub project. To achieve this, the hub has carried out a baseline assessment that included consultations with a diverse range of value chain partners from aggregators, processors and exporters in the region to create socio-economic impacts through the timely implementation of scientific activities. A significant achievement has been the setting of a benchmark for IPM cumin production compared to conventional methods, leading to the establishment of the brand "IPM Cumin", which fetches higher returns to the farming community. During the project implementation, the hub has established a major collaboration to facilitate procurement of cumin from the farm gate. It has worked with FPOs such as Green Desert FPO, Mundawa; Marwar FPO, Nagaur and Balaji FPO, Pali. Additionally, the project has partnered with processors and exporters including ITC, SRK Spices, PJM and Rapid Organics and Janta Global besides, seed spices association such as the Federation of Indian Spice Stakeholders (FISS), Rajasthani Association of Spices (RAS) and the Spices Board of India, Spice Park Jodhpur, APEDA, RSAMB and State agriculture department. By linking farmers directly to buyers, the hub has ensured the production of high-quality farm produce, implemented food safety testing, reduced transportation costs and mandi taxes, and provided better realization for the farmers and value chain partners.

6.11 Knowledge resources

Agricultural information sources played a pragmatic role in knowledge building among the farming communities, bridging the gap between science and society about good agricultural practices and technical intervention and their field applications. The hub released information leaflets on GAP and IPM in regional language to simplify the package of practices (Annexure 4). The presence of digital media and engaging print media assisted for early spread of technology to the farmers in remote areas so as to be utilized by them for successful production of IPM cumin.

6.12 Web based information system

An exclusive user-friendly website for the Biotech Kisan Hub for Western dry region was launched along with the implementation of the project. The website can be accessed at: www.biotechkisan.org. The online portal created a multiplier impact in information dissemination and supported the successful implementation of the project through GAP and IPM-based knowledge empowerment. Focused on the welfare of smallholder farmers, extension functionaries and processors and exporters, the website offers extensive resources on crop knowledge, good agricultural practices (GAP) and integrated pest management (IPM), an Agri Expert Network in Western Rajasthan, farm demonstrations, outreach activities comprising farmers' training, field visits, farmers' field day and technical webinars. It also includes a spice hub dedicated to the Western dry region. Other notable features of the site included a help center, a dedicated WhatsApp group "Mera Jaivik Kisan" and information on spices from local, national and international institutions. Additionally, the website features an interactive map showing the agri experts' network along with the details of agri experts from both public and private sector institutions who offer advice and guidance on GAP and IPM for seed spices in Western Rajasthan.

Field Demonstration and Capacity Building Program

In order to accelerate adoption and uptake of IPM cumin, the Biotech Kisan Hub has made visible footprints during the implementation of the project in the Western dry region, Jodhpur of Rajasthan from 2020 to 2023. Cumin is one of the strategically important and high value crops of Western Rajasthan. It was identified for large scale field demonstrations, on-farm training activities, capacity building programs and development of value chain systems among the other priority crops under the project. To provide technical assistance and laboratory services to targeted farmers, the hub has successfully set up a fully functionally tinkering lab at the field office of the South Asia Biotechnology Centre, Jodhpur, Rajasthan. The tinkering laboratory of the hub extended full technical support and carried out analysis of the large numbers of samples of soil & water, and germination tests to determine the soil health and provided right information on integrated nutrient management (INM). These services were crucial in helping farmers adopt the best agricultural practices for cumin cultivation. The hub has conducted baseline assessment including consultation with diverse value chain partners from farm inputs, aggregators, processors and exporters to create socio-economic impact in Western Rajasthan. Under the guidance of ICAR-NRCSS, the hub has identified and analyzed key problems faced by farmers in every step of the crop life cycle and provided workable solutions to tackle biotech and abiotic stresses for the production of quality cumin (Table 6). In that regard, the hub has supported large numbers of farmers to produce pesticide residue free cumin which is branded as 'IPM cumin', fetching considerably higher return to the farming community.

Table 6: Cumin production & value chain development: Gap analysis and key interventions

Activities	Problems faced by farmers (before project)	Solutions provided by Biotech Kisan Hub
GAP & IPM package of Practices (POP) Large Scale Field Demonstration	Lack of standard/ implementable POP Lack of scientific knowledge and awareness	GAP and POP on priority crops in collaboration with ICAR-NRCSS 47 Large scale adoption of GAP/IPM based production system and developing linkages between farmers, processors and exporters
Cost of Production	Higher cost of production due to excessive reliance on chemical pesticides	Reduced cost of production of cumin by 35-40% per acre
Strengthening Institutional Linkages:	Incoherence approach	Spices Board of India; Rajasthan State Agricultural Marketing Board (RSAMB) & Department of Agriculture; Agricultural and Processed Food Export Development

Activities	Problems faced by farmers (before project)	Solutions provided by Biotech Kisan Hub
		Authority (APEDA); ICAR-Directorate of Medicinal & Aromatic Plant Research (DMAPR); KVK Barmer; KVK, Jhunjhunu and Ambuja Cement Foundation, Nagaur & Pali
Technology Transfer	Lack of availability f bioproducts/lack of application of traps	GAP and IPM technologies developed by ICAR-NRCSS, Ajmer including field demonstration of sticky traps, botanicals and microbials to control *Fusarium* wilt, *Alternaria* blight, aphids and thrips
Branding IPM spices	IPM branded product demand ascertain from domestic/ international market	Developed & established brand of IPM cumin/spices to fetch 20-25% higher return to farming community
Premium Price for Farmers Produce	Lack of on farm procurement	IPM fetches 15-20% premium over the market price
Established Industry Partnership	Inadequate	ITC, Barmer; SRK Spices Ltd, Jodhpur; BKB Industries, Nagaur and Aachi Masala, Chennai; PJM Industries, Barmer and Rapid Organics, Sanchore
Linking with Farmers Producer Organization (FPO)	Inadequate	Balaji Farmers Producer Company, Soliyana, Rabariawas; Mundawa Marwar FPO Limited, Mundawa; Green Desert FPO; Jaitaran FPO

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2023

Second, the hub has curated a knowledge base, published posters and pamphlets and popularized POPs of cumin in English and Hindi in consultation with ICAR-NRCSS to improvise the production of IPM cumin during 2020-2023 (Annexure 4). Third, the hub laid out multiple field demonstrations of IPM cumin in clusters in identified districts of Western Rajasthan. The Biotech Kisan Hub through SABC, Jodhpur has carried out 37 IPM cumin demonstrations in Barmer, Jodhpur, Nagaur, Pali, Sanchore and Jalore districts of Western Rajasthan. In addition, the partner institute ICAR-NRCSS laid out 10 IPM cumin demonstrations in Nagaur district of Western Rajasthan. In total, the hub has laid out GAP & IPM based 47 cumin demonstrations in 5 districts covering Jodhpur, Pali, Nagaur, Jalore, Sanchore and Barmer of Western Rajasthan. Fourth, the project partners have organized 7 training programs with participation of 1,390 farmers; 8 technical webinars with 1,050 participants, 14 farmers field day programs involving 2,474 smallholder farmers and made 57 field visits to overseas different stages of growth of crops in demonstration fields. By the end of the project, 4,914 beneficiaries including 4,055 men and 859 women benefited from the activities of the hub. Fifth, the team has mobilized farmers producers' organizations namely Balaji FPO, Pali and Green Desert FPO, Marwar Mundwa to aggregate IPM cumin and has engaged multiple processors and exporters in training programs including ITC Ltd, SRK Spices, Jodhpur, PJM, Unjha & Rapid Organics, Sanchore for procurement of IPM cumin. Sixth, the hub has engaged a large numbers of cumin farmers in the Jodhpur, Nagaur, Pali, Barmer and Jalore-Sanchore districts and have shared knowledge and expertise gained through other forums such as the WTO-FAO STDF project, RSAMB and the Spices Board of India. Seventh, the hub has also extended soil and water testing to farmers engaged in field demonstrations and capacity building programs. Eighth, the hub in collaboration with the Spices Board of India has distributed tarpaulin to 60 cumin farmers including women farmers to improve quality, hygiene, and food safety of cumin and strengthen the value chain in Western Rajasthan. Ninth, the hub has awarded 6 mahila kisan biotech fellowships to progressive women farmers to popularize IPM cumin in Western Rajasthan. Finally, the hub has established collaboration with key agencies and diverse value chain partners such as the Spices Board of India, the

Figure 24: Glimpses of activities under the Biotech Kisan Hub

Source: Biotech Kisan Hub, South Asia Biotechnology Centre and ICAR-NRCSS, 2022

Rajasthan State Agricultural Marketing Board (RSAMB), Rajasthan Agriculture Department and APEDA and other NGO and associations such as Ambuja Cement Foundation, Federation of Indian Spice Stakeholders (FISS), Rajasthani Association of Spices (RAS), World Spice Organization, APMC Unjha, Spices Board of India, Spice Park Jodhpur, APEDA & RSAMB, ITC Ltd, McCormick, Rapid Organic, Janta Global, Swani Spice Pvt Ltd and SRK Spices. Continuing the engagement with cumin farmers of Western dry region, the biotech kisan hub has participated in 6 programs and hand holding 805 cumin farmers linking them with processors and spices industry and benefiting them post completion of the project after February, 2023.

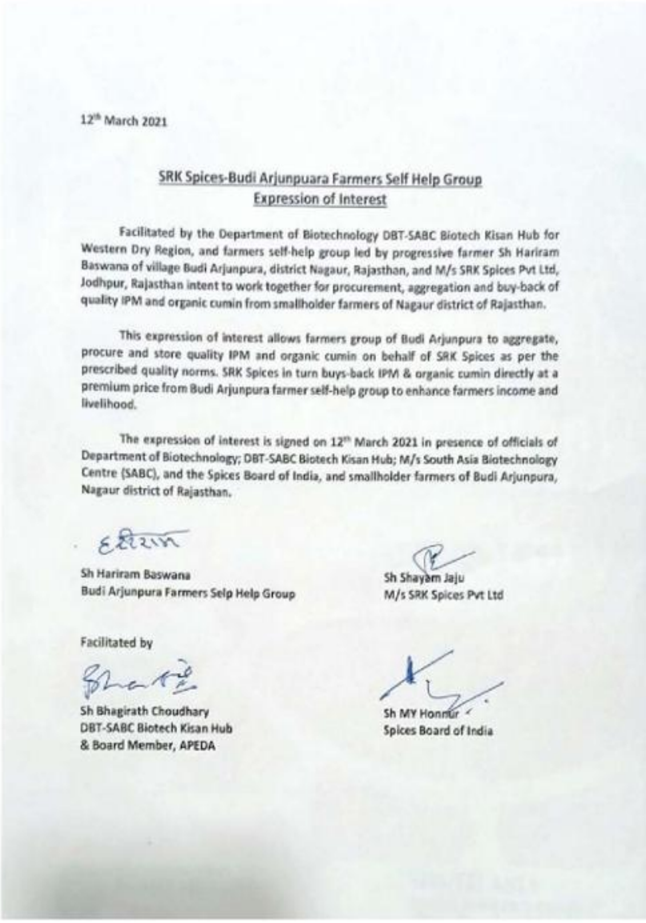
7.1 'IPM cumin' value chain development

The majority of cumin produced in Rajasthan is usually transported and sold in the Unjha APMC mandi of Gujarat, which not only costs enormous resources to farmers in loading, unloading and transportation along with uncertainty regarding market price at mandi system. One of the objectives of the Biotech kisan hub project was to bridge the gap and develop a value chain system on high value spice crops including cumin produced from Western Rajasthan (Figure 24). The hub successfully facilitated the production of pesticide residue-free cumin, compliant with both domestic and international sanitary and phytosanitary (SPS) norms. This enabled farmers to directly engage with the processors and exporters through self help groups (SHGs) and farmers producer organizations (FPOs), establishing buy-back arrangements for IPM cumin. By registering the farmers with the processors and exporters, the hub has developed a sustainable marketing and sourcing platform, ensuring fair returns to farmers and a stable supply chain. The value chain development for IPM cumin aimed at bringing the market to the doorstep of farmers and creating value for smallholder farmers of Western Rajasthan. It also addresses the issue of procurement by traders, pilferages, cost of transport and reduced drudgery and better realization on IPM cumin. Engaging with FPO was a way to pass on benefits directly to the cumin farmers. Developing a strong value chain partnership was a classic example of ensuring a fair price realization to cumin farmers for producing residue free and IPM cumin under the project.

During the project implementation, two expressions of interest (EOIs) were signed. One was between cumin farmers, represented through FPO Shri Balaji Farmers Producers Company Limited, Pali and ITC Ltd, Barmer, Rajasthan. The other was between a farmer SHG group from Budwara Arjunpura, Nagaur and SRK Spices Jodhpur in 2021 and 2022, in the presence of officials from the Department of Biotechnology (DBT) of the Government of India. These agreements facilitated the procurement, aggregation and buy-back of quality IPM and cumin from smallholder farmers of Nagaur and Pali districts of Rajasthan. While FPO Shri Balaji Farmers Producers Company Limited acted as an interface with ITC Ltd, the farmers group of village Budi Arjunpura facilitated to aggregate, procure and store quality IPM and organic cumin on behalf of SRK Spices Jodhpur as per the prescribed quality norms. These agreements ensured the purchase of IPM and organic cumin at premium prices, enhancing farmers' income and livelihoods.

The value chain development based on the area-wide adoption of GAP and IPM modules has not only significantly reduced the cost of production by 35-40% per acre but also fetched higher return for international quality produce by 25% (Annexure 5). This initiative exemplifies the successful creation of value through the direct engagement of farmers, FPOs, and spice companies. Figure 25 shows the example of value chain creation by signing expressions of interest (EOIs) between farmers engaged in Biotech Kisan Project, FPO and spices companies.

Figure 25: Signing of expression of interest between the Biotech kisan project farmers and spices companies



12th March 2021

SRK Spices-Budi Arjunpuara Farmers Self Help Group
Expression of Interest

Facilitated by the Department of Biotechnology DBT-SABC Biotech Kisan Hub for Western Dry Region, and farmers self-help group led by progressive farmer Sh Hariram Baswana of village Budi Arjunpura, district Nagaur, Rajasthan, and M/s SRK Spices Pvt Ltd, Jodhpur, Rajasthan intent to work together for procurement, aggregation and buy-back of quality IPM and organic cumin from smallholder farmers of Nagaur district of Rajasthan.

This expression of interest allows farmers group of Budi Arjunpura to aggregate, procure and store quality IPM and organic cumin on behalf of SRK Spices as per the prescribed quality norms. SRK Spices in turn buys-back IPM & organic cumin directly at a premium price from Budi Arjunpura farmer self-help group to enhance farmers income and livelihood.

The expression of interest is signed on 12th March 2021 in presence of officials of Department of Biotechnology; DBT-SABC Biotech Kisan Hub; M/s South Asia Biotechnology Centre (SABC), and the Spices Board of India, and smallholder farmers of Budi Arjunpura, Nagaur district of Rajasthan.

हरिराम

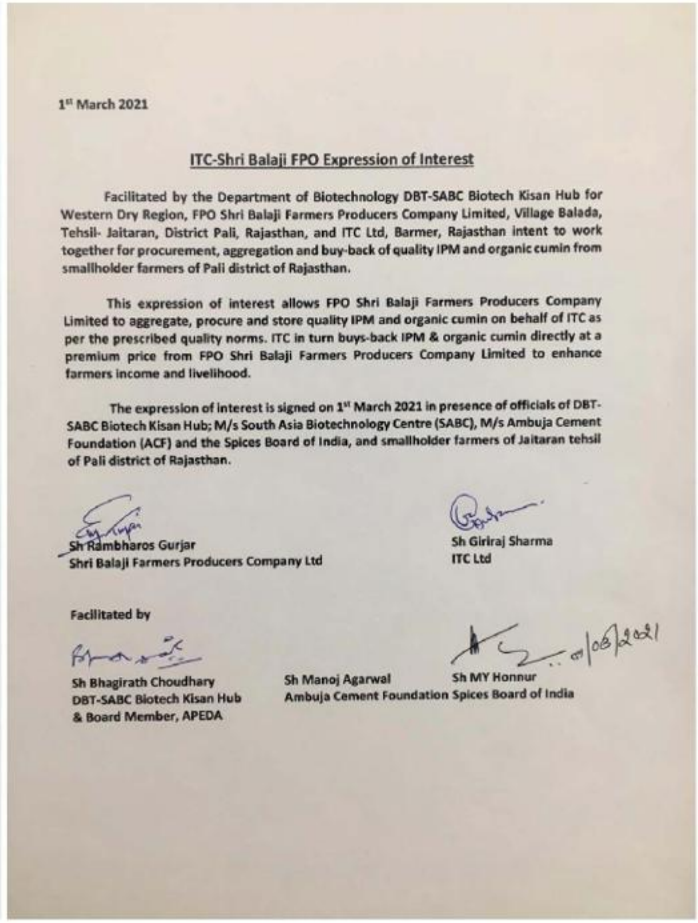
Sh Hariram Baswana
Budi Arjunpura Farmers Selp Help Group

Sh Shayam Jaju
M/s SRK Spices Pvt Ltd

Facilitated by

Sh Bhagirath Choudhary
DBT-SABC Biotech Kisan Hub
& Board Member, APEDA

Sh MY Honnur
Spices Board of India



1st March 2021

ITC-Shri Balaji FPO Expression of Interest

Facilitated by the Department of Biotechnology DBT-SABC Biotech Kisan Hub for Western Dry Region, FPO Shri Balaji Farmers Producers Company Limited, Village Balada, Tehsil- Jaitaran, District Pali, Rajasthan, and ITC Ltd, Barmer, Rajasthan intent to work together for procurement, aggregation and buy-back of quality IPM and organic cumin from smallholder farmers of Pali district of Rajasthan.

This expression of interest allows FPO Shri Balaji Farmers Producers Company Limited to aggregate, procure and store quality IPM and organic cumin on behalf of ITC as per the prescribed quality norms. ITC in turn buys-back IPM & organic cumin directly at a premium price from FPO Shri Balaji Farmers Producers Company Limited to enhance farmers income and livelihood.

The expression of interest is signed on 1st March 2021 in presence of officials of DBT-SABC Biotech Kisan Hub; M/s South Asia Biotechnology Centre (SABC), M/s Ambuja Cement Foundation (ACF) and the Spices Board of India, and smallholder farmers of Jaitaran tehsil of Pali district of Rajasthan.

Sh Rambharos Gurjar
Shri Balaji Farmers Producers Company Ltd

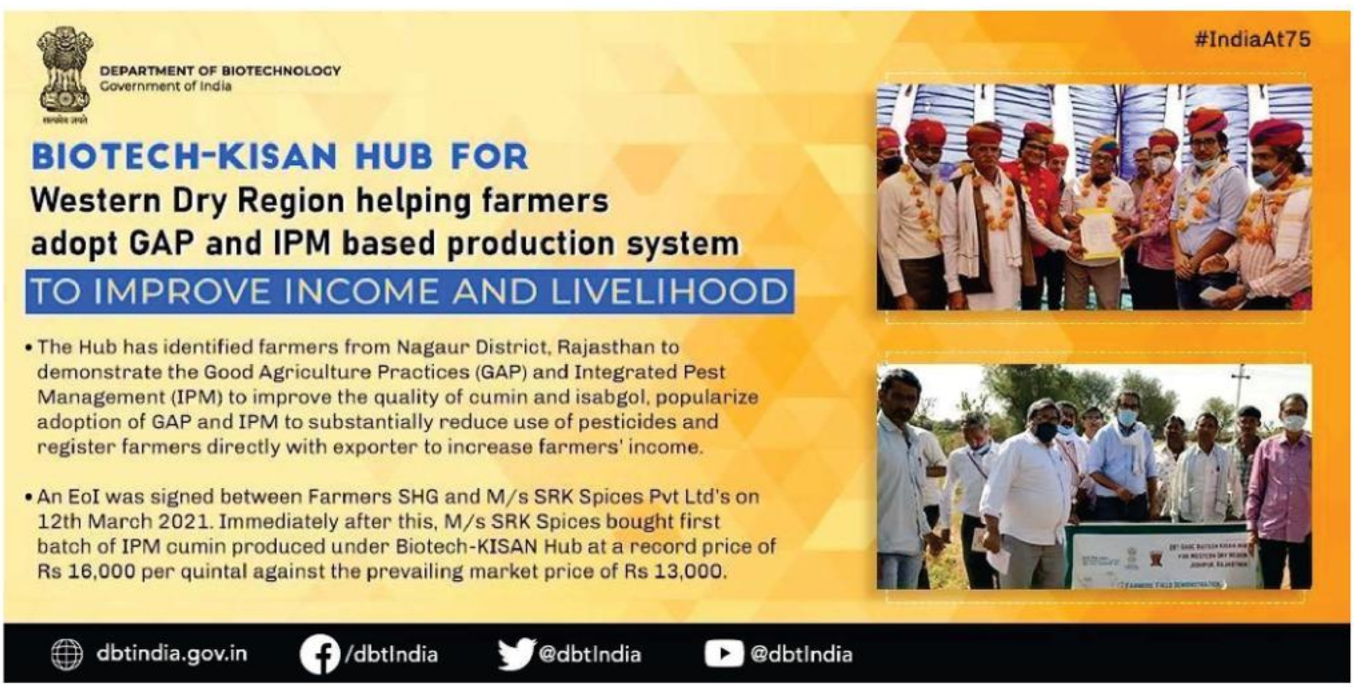
Sh Giriraj Sharma
ITC Ltd

Facilitated by

Sh Bhagirath Choudhary
DBT-SABC Biotech Kisan Hub
& Board Member, APEDA

Sh Manoj Agarwal
Ambuja Cement Foundation

Sh MY Honnur
Spices Board of India



Source: Department of Biotechnology, 2022

7.2 Media engagement and social media messaging

The hub has generated massive news coverage based on its knowledge, insights and field activities to amplify the outcome of the project activities (Figure 26). Popular news articles were published by both local and national media including Rajasthan Patrika, Indian Express and Hindu Business Line etc. This extensive news coverage by multiple print and online media have been archived on the Biotech Kisan Hub website at: http://biotechkisan.org/news.html

In addition to media coverage, the project has also generated an array of knowledge resource, posters and pamphlets and content of field activities in a digital educational mode, which is made available online through Biotech Kisan Hub website at: http://biotechkisan.org/photos-videos.html

Figure 26: Massive news coverage and newspaper articles

ITC partners with farmers' body to procure pesticide residue-free cumin from Rajasthan

OUR BUREAU

Bengaluru, March 1

A farmers' producer organisation, Shri Balaji Farmers Producers Company Ltd. and Kolkata-based multinational conglomerate ITC Ltd have agreed to work together for procurement, aggregation and buyback of quality IPM and organic cumin (jeera) from small farmers of Jaitran tehsil of Pali district of Rajasthan.

This collaboration is an outcome of Department of Biotechnology (DBT) South Asia Biotechnology Centre's Biotech Kisan Hub project, which is promoting integrated pest management (IPM) and good agriculture practice (GAP) among cumin farmers in Western Rajasthan.

"Our farmers will benefit by this collaboration with ITC and we will get premium price for IPM and organic cumin produced by most backward farmers of our region," said Rambharos Gurjar, CEO of Shri Balaji FPC, in a statement.

Rajasthan produces about two-thirds of total cumin grown on over 6.76 lakh hectares. Implementing the IPM package will minimise the use of pesticides application while promoting the use of microbes, botanicals and sticky traps to monitor and control major pests such as aphids and thrips.

"IPM cumin is the future of farming and can fetch 10-20 per cent premium price to growers in Rajasthan. There is a potential international market for the residue free IPM cumin from countries such as Japan, EU and USA that could help our farmers to improve their incomes and transform livelihoods," said Bhagirath Choudhary of the DBT-SABC Biotech Kisan Hub and technical member of Apeda.

The Spices Board of India Jodhpur office has laid emphasis on backward integration and buy back arrangement to increase price realisation of IPM cumin produced in different districts of Western Rajasthan. "The Spices Board of India is proactively collaborating with DBT-SABC Biotech Kisan hub, ICAR-NRCSS and State Agriculture Department to increase farmers' income in Rajasthan," said MY Honnur of the Spices Board.

किसानों को कृषि की उन्नत जानकारी दी, जैविक खेती की बताई उपयोगिता

आईपीएम जीरा उत्पादन को लेकर अर्जुनपुरा में किसान मेले का आयोजन

केवल दो माह में तैयार होगी मूंग की फसल

पहली बार किसान मेले का आयोजन

एक साल तक हर माह मिलेंगे 10 हजार रुपए

कविता को महिला किसान बायोटेक फैलोशिप

पत्रिका न्यूज नेटवर्क

rajasthanpatrika.com

नागौर. जिले के कलाया गांव की कविता शिवकरण को बायोटेक-कृषि इनोवेशन साइंस एप्लीकेशन नेटवर्क (बायोटेक किसान हब फॉर वेस्टर्न ड्राई रीजन) मिशन कार्यक्रम के तहत महिला किसान बायोटेक फैलोशिप के लिए चुना गया है। इसके तहत महिला कृषक को दक्षिण एशिया जैव प्रौद्योगिकी केंद्र (एसएबीसी), जोधपुर और राष्ट्रीय बिजीय मसाला अनुसंधान केंद्र (एनआरसीएसएस), अजमेर द्वारा कार्यान्वित पश्चिमी शुष्क क्षेत्र के लिए डीबीटी बायोटेक किसान हब के तहत वर्ष 2021-22 के लिए 10 हजार रुपए प्रति माह की फैलोशिप राशि प्रदान की जाएगी।

कविता

कलाया गांव में 14 जुलाई को आयोजित सम्मान समारोह में कविता को यह सम्मान प्रदान किया गया। फैलोशिप से सम्मानित होने पर कविता ने इसे महिलाओं का सम्मान बताया और भारत सरकार विज्ञान और प्रौद्योगिकी मंत्रालय के जैव प्रौद्योगिकी विभाग व दक्षिण एशिया जैव प्रौद्योगिकी केंद्र (एसएबीसी) जोधपुर और एनआरसीएसएस अजमेर का आभार जताया।

राजस्थान की पहली महिला बनी कविता

इस अवसर पर एसएबीसी जोधपुर के डॉ. भागीरथ चौधरी ने कविता को बधाई देते हुए कहा कि कविता का चयन दक्षिण एशिया जैव प्रौद्योगिकी केंद्र के अध्यक्ष डॉ. सीडी माई के नेतृत्व में चयन समिति ने किया। उन्होंने बताया कि ऐसा पहली बार हुआ है कि राजस्थान की किसी महिला किसान को इस फैलोशिप के लिए चुना गया है। यह परियोजना किसानों को अच्छी फसल मिले, इसके लिए प्रशिक्षण का काम करती है, ताकि उन्हें अपनी फसल का ज्यादा से ज्यादा दाम मिल सके। कविता भी अब इसकी टीम के साथ मिलकर काम करेगी और अपने सर्किल के किसानों को प्रशिक्षित करेगी। कविता का चयन रबी-2020 में जीरा के आईपीएम आधारित क्षेत्र प्रदर्शन के कार्यान्वयन में उसके प्रदर्शन और भारत सरकार के जैव प्रौद्योगिकी विभाग की परियोजना संचालन और इस संबंध में निगरानी समिति (पीएसएमसी) के सदस्यों के साथ बातचीत के आधार पर हुआ है।

ये भी रहे उपस्थित

सम्मान समारोह के दौरान डॉ. एसएस मीणा, डॉ. मुरलीधर मीणा, डॉ. नरेश व डॉ. संदीप आगले, कृषि अर्थशास्त्री डॉ. विकास पावड़िया आदि मौजूद रहे। कलाया के साबूराम काला, अर्जुनराम, कोजाराम, नरपत, जयपाल व शिवकरण सहित अन्य ग्रामीण मौजूद रहे। इस मौके पर वैज्ञानिकों ने खेत में खड़ी चालीस दिन की कपास की फसल का निरीक्षण किया और फसलों पर कीट की समस्या का समाधान बताया। वैज्ञानिकों ने खेत की मिट्टी आदि के नमूने लिए और कपास माइट की समस्या के समाधान पर सलाह दी।

SABC teams up with Rajasthan farmers to promote IPM cumin

FE BUREAU
New Delhi, November 3

THE SOUTH ASIA Biotechnology Centre (SABC), a Jodhpur-based policy advocacy group in improving crops quality, has teamed up with farmers in western Rajasthan to promote IPM cumin, which commands 10-20% higher rates than the normal variety due to its demand in the export market.

The organisation plans to include more seed spice crops like fenugreek, isabgol and fennel under its programme to help farmers realise better prices. "We have developed a module which farmers are using to produce cumin without pesticide residue ... IPM cumin becomes the first preference of the exporters as it does not have any stress of residue," said Bhagirath Choudhary, director of SABC.

To intensify IPM cumin production, the SABC has collaborated with the Department of Biotechnology, Spices Board and ICAR's National Research Centre on Seed Spices

To intensify IPM cumin production in Barmer and other districts of Rajasthan — India's biggest producer of cumin — the SABC has collaborated with the Department of Biotechnology, Spices Board and ICAR's National Research Centre on Seed Spices.

The area under cumin in Barmer was 1,71,482 hectare in 2019-20, which is almost a quarter of the state's total acreage under the crop. But the yield in Barmer is one of the lowest in the state at less than five quintal/hectare as against eight quintal/hectare in Jodhpur, Choudhary said.

"IPM cumin is the future of cumin farming in Barmer. Farmers were struggling to manage insect pests such as aphids and thrips with the current production practices. As part of the DBT-SABC biotech Kisan hub, we have introduced a new concept of managing pests with proper use of yellow and blue sticky trips, biological and botanical," Choudhary said. He said farmers are very supportive of the practices.

Cost-Benefit Analysis and Socio-Economic Impact

The cost-benefit analysis and economic impact of the Biotech Kisan Hub project were evaluated based on the success of the exemplary farmers adopting the best practices involving good agricultural practices (GAP) and integrated pest management (IPM) for the pesticide residue-free production of cumin. The socio-economic impact of the area-wide adoption and dissemination of technical know-how about IPM cumin was quantified with the help of ICAR-NRCSS. The impact evaluation revealed that the GAP and IPM production technique has emerged as a viable method to produce residue-free cumin, leading to the popularization of brand 'IPM cumin' in Western Rajasthan.

The hub has identified appropriate technologies and deployed interventions at multiple levels including soil & water testing based INM practices, distribution of quality seeds, application of biological seed treatments, shifting farmers from broadcasting seeds to line sowing in cumin cultivation, application of decomposed FYM with *Trichoderma viride,* adoption of integrated pest management (IPM). These practices included installation of sticky traps, utilizing botanical & microbial, application of approved pesticides and implementation of pre harvest interval (PHI) to comply with domestic and global standard on pesticide residue, and engaging FPO as interface to develop backward integration. These technological interventions were critically implemented to manage sucking pests, *Fusarium wilt* and *Alternaria blight* in cumin. Among the pests, aphids and thrips infest the crop during February & March at the blooming stage and could potentially cause significant yield losses. Annexure 5 calculates the comprehensive cost of cultivation for each intervention and return on investment of cumin in Rajasthan during 2022-23 and 2023-24. For minimizing population of sucking pests and their vectors, around 25 yellow and 25 blue traps per acre have proved satisfactory while regularly monitoring for aphids & thrips incidence for its ETL of 5-10 aphids or thrips per leaf or per shoot for recommended biological and chemical approaches. Amongst diseases like wilt caused by *Fusarium oxysporum* occurs at the early stage, blight caused by *Alternaria barnsii* occurs at flowering stage and powdery mildew caused by *Erysiphae polygoni* in late stage may possibly turn into epidemic forms. In order to manage integrated practices to create an unfavorable environment for disease development, avoidance and removal of diseases, inoculation of cultural, chemical and biological measures have been strictly followed as per the recommendation of labels approved by CIB&RC of the Ministry of Agriculture and Farmers' Welfare. Cumin farmers were advised to follow the procedures for post-harvest management like cleaning, grading, packing, transporting and storing of grains so as to realize a better market price. At the same time, the hub ensured that the exportable cumin adhered to standard limits as per the recommended physical and chemical substances and microbial load for both whole seed and powder. Table 7 shows enhancement in income from different technologies and interventions before and after the implementation of the Biotech kisan hub project in the Western dry region.

The benefits of the project were derived from GAP and IPM production of cumin & buy-back arrangement through FPOs to encourage on-farm gate purchase. The group of demo farmers of Budi Arjunapura cluster have signed buy back agreement with M/s SRK Spices Pvt Ltd while Pali cluster farmers with M/s ITC Pvt Ltd. On average, IPM cumin fetched a premium of around 24% over the market price for demo farmers of the hub in both clusters. Moreover, the IPM based production lowered the cost of production of cumin by 25-35% per acre by effectively controlling fungal diseases and insect pests.

Table 7: Enhancement in income from different technologies and interventions

S.No.	Name of the interventions/ technology transferred	Change in income	
		Before	After
1.	Soil & water testing based INM practices	N, P, K, S, organic matter	N (30-33% reduction)
2.	Biological seed treatment & quality seed (SRR)	Seed germination 65% cumin	80% in cumin
3.	Line sowing in cumin cultivation	Seed rate reduced from 15 kg/ha	5-6 kg/ha in cumin
4.	Decomposed FYM with Trichoderma viridae	Wilt attack	Reduction in wilt attack
5.	IPM (Sticky traps with Botanical & microbial application)	Pest infestation (30-45 aphids per umbel)	Reduce in pests (15-18 aphids per umbel)
6.	PHI & % moisture (Harvesting)	Not available	On Farm moisture measurement for procurement
7.	FPO & Backward integration	Negligible on farm procurement	10-15 companies associated for procurement
8.	IPM cumin yield	4-5 q/ha	5.5-6 q/ha

Source: Biotech Kisan Hub, South Asia Biotechnology Centre, 2022

The hub has also promoted mandatory sampling and testing for pesticide residue in the exportable consignments of cumin in view of strict quality norms of importing countries. A handful of NABL accredited laboratories were identified for testing IPM cumin including Eureka Analytical Services, Eurofin India Laboratory, AVES Lab, SGS India Laboratory Testing Services, Tentamus India Labs for Life, Ned Spices Lab and ITC Testing Lab to name a few (Table 8). By 2022-23, the private procurement companies such as ITC, McCormick, Ned Spices, Rapid Organic, Janta Global & SRK Spices etc procured an estimated 37,500 metric tons of IPM cumin based on 10,700 samples tested for pesticide residue sourced from the major cumin growing districts such as Barmer, Jaisalmer, Sanchore-Jalore, Nagaur and Jodhpur of Western Rajasthan (Table 9). The quantum of farm-gate procurement of IPM cumin not only signifies the quality of the produce but also increases income and enhances the financial prospects of cumin farmers. Moreover, the market price of cumin produced in the Western Rajasthan has increased from an average ₹ 18,000 per quintal in 2019-20 which was peaked at ₹ 45,000 per quintal in 2022-23 and subsequently stabilized around ₹ 25,000 per quintal in 2023-24 with the large-scale adoption of IPM technology resulting in the quality production of cumin in the last 4-5 years (Table 9). In summary, the Biotech Kisan Hub implemented jointly by SABC, Jodhpur and ICAR-NRCSS, Ajmer has triggered the adoption of IPM cumin production and popularization of 'IPM cumin', which is the shining example of the success of IPM technology in Indian agriculture. Like IPM grapes in Maharashtra, Rajasthan could emerge as a hub for production and export of quality IPM cumin and other spices such as coriander, fennel & fenugreek, which can transform the income, livelihood and socio-economic growth of the farmers of Western dry region of Rajasthan.

Table 8: List of analytical labs for testing IPM cumin in Rajasthan

S. No.	Analytical lab	Location	No. of sample tested
1.	Eureka Analytical Services	Shiv, Barmer, Rajasthan	3,500
2.	Eurofin India Laboratory	Unjha, Gujarat & Barmer, Rajasthan	2,500
3.	Aves Lab: Research and Analysis Centre	Unjha, Gujarat	1,500
4.	SGS India Laboratory Testing Services	Thaltej, Ahemdabad, Gujarat	300
5.	Tentamus India Labs for Life	Quthbullapur, Hyderabad, Telagana	500
6.	Ned Spices Lab	Mahuya, Bhavnagar, Gujarat	500
7.	ITC Testing Lab	Manesar, Gurgaon, Haryana	800
8.	OLAM Lab (Quality Control Laboratory- OLAM Agro India Ltd.)	Rajkot, Gujarat	600
9.	Others including Fare lab etc.	-	500
	Total sample tested		10,700

Source: Industry partners of IPM Cumin, analyzed by South Asia Biotechnology Centre, 2024

Table 9: List of Industries engaged in sourcing IPM cumin from Rajasthan

S. No.	Company	Location	Material Procured (Metric Tons)
1.	ITC Pvt. Ltd.	Alakhdara, Jodhpur, Rajasthan	8,000
2.	Laxmi Enterprises	Jodhpur, Rajasthan	7,000
3.	OLAM International (OLAM Food Ingredients)	Jaisalmer, Rajasthan	4,000
4.	K.J. (J.K. Spices and Food Products)	Amratolla street, Kolkata, West Bengal	2,000
5.	MM International		2,000
6.	AVT McCormik Ingredients Pvt Ltd.	Aluva, Kochi, Kerala	1,500

S. No.	Company	Location	Material Procured (Metric Tons)
7.	Jikaka Pvt Ltd	Barmer, Rajasthan	1,500
8.	Uttamlal Popat Chand		1,500
9.	Ned Spice	Pratap Nagar, Jodhpur, Rajasthan	1,200
10.	Janta Global	Barmer, Rajasthan	1,000
11.	PJM Industries	Unjha, Gujarat	1,000
12.	Synthite	Synthite Valley, Kolenchery, Kerala	800
13.	Swani Spice Pvt Ltd	Jaisalmer, Rajasthan	800
14.	AB Mauri India	Kochi, Kakkanad, Kerala	700
15.	Griffith Foods	Varadanahalli, Karnataka	500
16.	Value Ingredients	Chennai, Tamil Nadu	500
17.	Mangilal Jamadas	Unjha, Mehsana, Gujarat	500
18.	SRK Spices	Maderana Colony, Jodhpur, Rajasthan	500
19.	Rapid Organic Pvt Ltd.	Sanchore, Rajasthan	500
20.	Others including Kanaiya Exports, MR Agro, Asian Spices, Krishify, Vallon, Jayanti, Jeerawala, Earth Food, Adani etc	-	2,000
	Total IPM cumin		**37,500**

Source: Industry partners of IPM Cumin, analyzed by South Asia Biotechnology Centre, 2024

Annexure 1

Step-by-step approaches for improving yield and quality of cumin

Pre planting Field preparation, seed treatment & nutrient management	**Planting** Sowing methodology	**Post planting** Weed, pest, pathogen and nutrient management	**Harvest**	**Post-harvest**
Dos ● **Field preparation:** 15 days prior to planting. Only two cross ploughing, adding 10 tons FYM or 5 tons vermicompost/ha & soil treatment with *Glomus fasciculatum* to improve soil health. Addition of sheep manure @ 5 tons/ha ● **Fertilizer application:** Basal dose of 15:15:00 kg Nitrogen & Phosphorus per hectare at the time of sowing ● **Varieties and seed rate:** Always use good quality GC-4 seeds at a seed rate of 12 kg/ha. Pre-soaking of seed in water: (4-6 hrs). Seed drying in shade for almost 6-7 hrs ● **Seed treatment:** Just at pre-planting time (4-6 hrs) prior to crop sowing. Apply	● **Time of sowing:** Mid October to mid of November ● **Temperature:** 15-30 ● **Sowing protocol:** Shallow sowing at 1-1.5cm depth either by broadcasting at 12-15 kg/ha seed rate or by line sowing method using vacuum drill @ 30×10cm ● **Pre-emergence weed management:** Apply pre-emergence weedicides Pendimethalin 30 EC% @3.25 l/ha	● **Irrigation:** First irrigation after 5-6 days of sowing for proper germination. Subsequently, give irrigation at crucial stages of plant growth. Altogether 4 irrigations are required ● **Hand weeding:** 2-3 weeding and hoeing is essential at 30-35, 50-60 DAS & removal of Jeeri before flowering ● **Nutrient management:** Apply 15 kg Nitrogen per hectare after 30 DAS ● **Disease management:** ***Fusarium* wilt-** Foliar application and drenching of roots with *Trichoderma viride* and *Pseudomonas fluorescens* at 6 ml/litre ***Alternaria* blight-** Spray *Tebuconazole* 50% + *Trifloxystrobin* @ 25% / 0.6 g/l or Zineb 68% + *Hexaconazole* @ 4 % @ 2 g/l or *Metirum*	● **Harvesting at physiological maturity:** 7-8 days prior to real maturity or at 80-90 days after sowing ● Mass harvesting of mature plants by uprooting in morning only	● **Harvested crop:** Keep the bundles of harvested cumin on the tarpaulin or cement floor ● **Sun drying:** dry the crop in sunlight for 3-4 days for 10-12% moisture content of grains ● **Threshing:** Threshing of grain either by wooden stick or thresher on clean Tarpaulin or cemented floor, no addition of mixture be allowed ● **Grading:** Grading the grains through a sieve so that sand, clay, stalks, leaves and weak grains are removed. ● **Packaging:** Store cleaned bags, in ventilated, dry and cool places with date tags ● **Storage:** Store the plastic bags filled with cumin on wooden planks

Trichoderma viride @10 g/kg seed along with *Pseudomonas fluorescens* @8gm/kg of seed to control fungal diseases. Also treat seeds with *Mycorrhiza* @10 g/kg helps to uptake of nutrient for plant growth ● **Irrigation**: One deep 6cm irrigation with good quality surface irrigation for initiating emergence		55% + *Pyraclostrobin* @ @3.5 g/l **Powdery mildew-** Sulfur dusting at 10 kg/acre or Dinocap (*Karathane*) 48% EC @ 1.0 ml/l ● **Sucking pest management:** **Monitoring**-Install 25 yellow and 25 blue Sticky Traps for mass trapping, regularly monitor for Aphids & Thrips incidence **Aphids & Thrips:** **Biocontrol-** Spraying of Neem oil 10,000 ppm with 10 ml per liter of water and *Lecanicillium lecanii* @ 4 g/l **Chemical control:** Spray *Tolfenpyrad* 15% EC 2 ml/l or *Thiamethoxam* 25% WG 0.2 g/l or *Spirotetramat* 150 OD @ 1.0 ml/l or *Carbosulfan* 25% EC @ 2.5 ml/l ● **Cold & frost:** Irrigation and spraying of Sulphuric Acid 0.1% between 60-80 DAS (January to mid of February)		properly in the warehouse and keep them away from moisture. ● **Standard:** National and international norms and standards for storing leading to exporting cumin be adopted
Don'ts ● No deep ploughing and making the soil powdery, mixing of manure in the soil before planting	● Avoid delayed sowing ● Avoid deep and shallow sowing of seeds	● Avoid planting of mustard, wheat, castor, isabgol near cumin crop ● Avoid flood irrigations and water logging ● Avoid irrigation in humid and warm weather	● No irrigation prior to 7-8 days of harvesting	● Not more than 8-10% moisture content in dry seeds

Annexure 2

Standardization limits for different quality factors in Cumin

S. No.	Requirements	FSSAI	ISO	CAC	MRL ESA USDA	ASTA/	GCC
1.	Moisture content, % by mass (maximum)	10	9	≤10	-	9	9-13
2.	Total ash, % by mass on dry basis (maximum)	12	8.5	8.5-12	-	9.5	8.5-12
3.	Acid insoluble ash, % by mass on dry basis (maximum)	4	1.5	1.5-4	-	2	1.5-4
4.	Volatile oil content, ml/100g, on dry basis (minimum)	1.5	2	1.5-2	-	2	1.5-2
5.	Extraneous vegetable matter content, % by mass (maximum)	3	1-3	1-3	1	0.5	1-3.5
6.	Foreign matter content, % by mass (maximum)	0.5	0.5	0.1-0.5	2	0.5	
7.	Mouldy seeds, % by mass (maximum)	1	-	1	-	-	-
8.	Proportion of damaged/defective fruits, % by mass (maximum)	5	5	5	-	-	-
9.	Broken, % by mass (maximum)	3	-	-	-	-	5
10.	Dead insects, insect fragments, rodent contamination, % by mass (maximum)	0.5	1	0.1-0.5	-	1	-
11.	Insect-damaged matter, % by mass (maximum)	1	-	0.5-1	-	-	1
12.	Animal excreta, mg/kg, (maximum)	1	-	1	-	0.3	
13.	Uric acid, mg/kg on dry basis (maximum)	100	-	-	-	-	
14.	Aflatoxin (total), µg/ kg	30	-	-	≤5	20	-

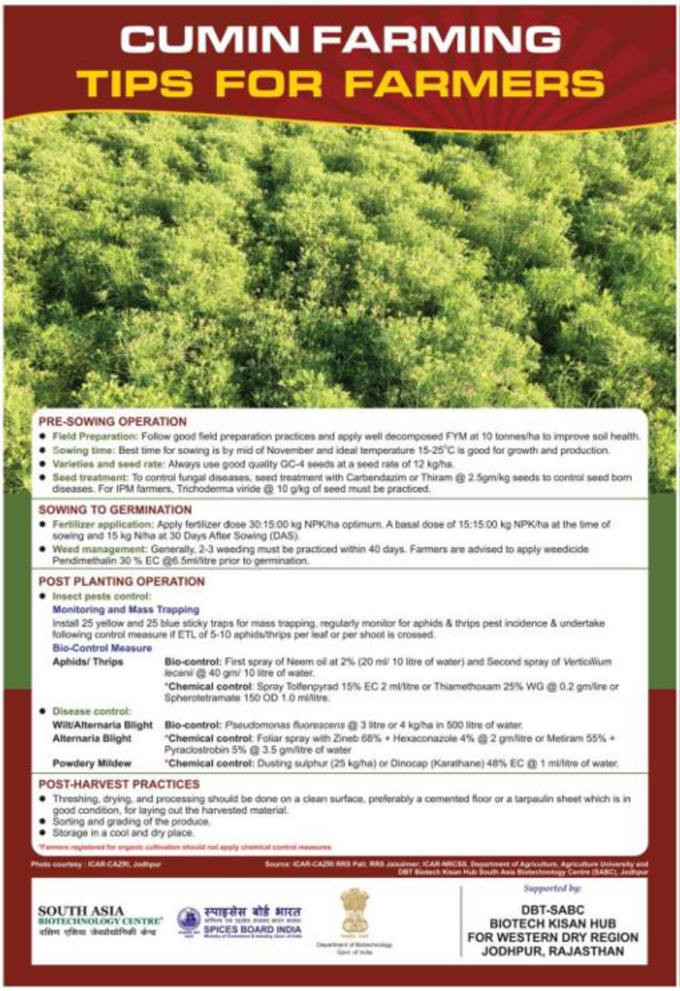
Annexure 3

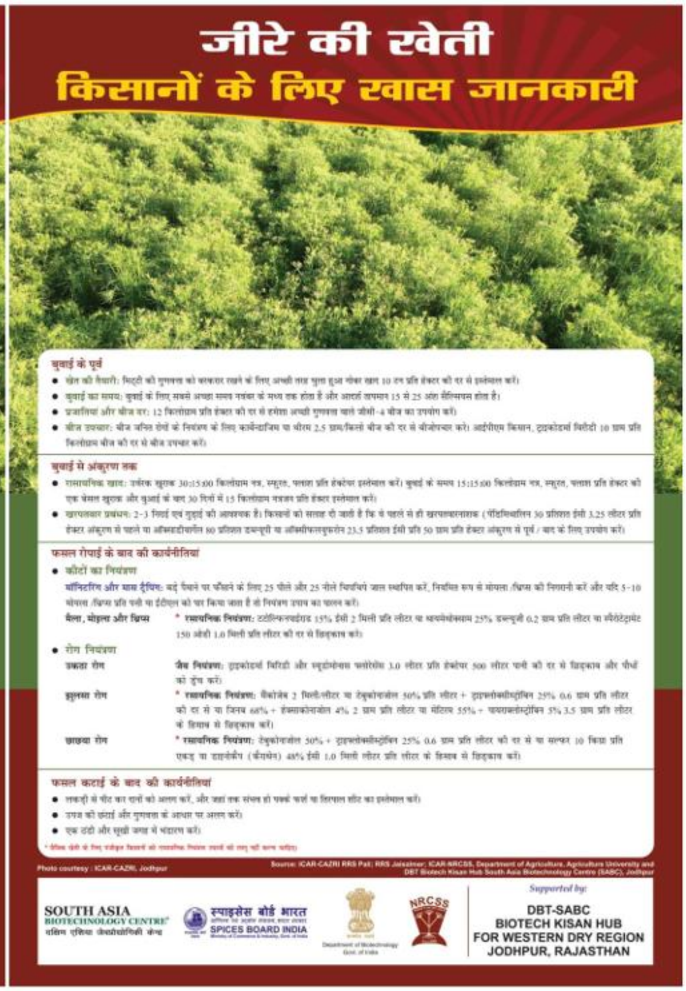
Soil health card for cumin cultivation

S. No.	Village	Date	Area (acre)	Soil quality	Recommendation
1.	Baodi, Jodhpur	2 Nov. 2021	1	K, P and S deficient	Phosphorous 6 kg/acre Gypsum 120 kg/acre
2.	Budi, Arjunpura	2 Nov. 2021	1	N, P, S, B, Zn, Cu, Fe, Mn	Nitrogen 96-190 kg/acre Phosphorous 4.4-8.8 kg/acre Gypsum 120 kg/acre Borax 4 kg/acre Zinc sulfate 10 kg/acre Copper sulfate 4 kg/acre Iron sulfate 40 kg/acre
3.	Jaitaran	10 Nov 2021	1	N, P, B, Zn, Cu, Fe, Mn Deficient	Nitrogen 96-190 kg/acre Phosphorous 4.4-8.8 kg/acre Borax 4 kg/acre Zinc sulfate 10 kg/acre Copper sulfate 4 kg/acre Iron sulfate 40 kg/acre
4.	Kurki	10 Nov 2021	1	N, P, S, B, Zn, Cu, Fe, Mn	Nitrogen 96-190 kg/acre Phosphorous 4.4-8.8 kg/acre Gypsum 120 kg/acre Borax 4 kg/acre Zinc sulfate 10 kg/acre Copper sulfate 4 kg/acre Iron sulfate 40 kg/acre
5.	Balaya	27 Dec. 2021	2	N, P, Zn, Cu, Fe, Mn deficient	Nitrogen 12 kg/acre Phosphorous 6kg/acre Zinc sulfate 10 kg/acre Copper sulfate 4 kg/acre Iron sulfate 40 kg/acre Manganese sulfate 50 kg/acre
6.	Khedapa	27 Dec. 2021		N, P, Zn, Cu, Fe, Mn deficient	Nitrogen 12 kg/acre Phosphorous 6 kg/acre Zinc sulfate 10 kg/acre Copper sulfate 4 kg/acre Iron sulfate 40 kg/acre Manganese sulfate 50 kg/acre
7.	Dhingsara	2 Nov. 2021	1	N, P, B, Zn, Cu, Fe, Mn Deficient	Nitrogen 96-190 kg/acre Phosphorous 4.4-8.8 kg/acre Borax 4 kg/acre Zinc sulfate 10 kg/acre Copper sulfate 4 kg/acre Iron sulfate 40 kg/acre

Annexure 4

Information leaflets, GAP practices chart for IPM cumin and handouts generated by SABC, Jodhpur for pest and disease management





Annexure 5

Cost of cultivation of cumin in Rajasthan, 2022-23 and 2023-24

Component	Quantity	Rate	Cost per hectare 2023-24 (Without Demo)	Cost per hectare 2023-24 (Demo)
A2 Components				
Ploughing (rotavator, cultivator and leveller)	8 hrs	₹900 per hour	₹7,200	₹7,200
Organic Fertilizers/FYM	3 trolly manure	₹3600 per trolly	₹10,800	₹10,800
Soil Amendments	2.5 kg *Trichoderma* & 100 kg gypsum	₹150 per kg *Trichoderma* 2.20 per kilo	₹595	-
Chemical Fertilizers	2 bags of Urea 2 bags of DAP 18 kg micronutrient 1.25 litre weedicide	270 kg bag of 45 kg 1350 kg bag of 50 kg 100 per kg micronutrient 700 per liter weedicide	₹5,915₹	₹5,915
Seeds	15 kg/ha	1000 per kg	₹15,000	-
Seed Treatment	100 gm *Trichoderma*	150 per kg	₹150	-
Irrigation cost	4 irrigations @8 days	100 /HP @40 HP (4000/month)	₹1,066	₹1,066
Maintenance of irrigation equipment		285/month/ ha	₹1,142	₹1,142
Pest & Disease Management	3 times spray		₹3,200	₹2,000 (2 times spray)
Threshing	3 hours	1200 /hr	₹3,600	₹3,600
Packing	14 bags /ha	100/bag	₹1,400	₹1,400
Crop Insurance	Premium	4514 /ha	₹4,514	₹4,514
Total input cost			₹54,582	₹37,638
Agriculture Loan Interest		0.75 % monthly interest rate for 6 months	₹2,456	₹2,456
Total A2 Cost			**₹57,038**	**₹40,094**

Component	Quantity	Rate	Cost per hectare 2023-24 (Without Demo)	Cost per hectare 2023-24 (Demo)
Family Labour (FL)				
Labour Cost for Sowing	2.5 hrs	200 per hour	₹500	₹500
Cost of Irrigation	4 irrigation@ 2 day/ irrigation for 8 days	400 per irrigation	₹3,200	₹3,200
Cost of Harvesting	18 labours	400 /labour	₹7,200	₹7,200
Cost of Threshing	5 labour for 3 hours	200 /labour/ hour	₹3,000	₹3,000
Cost of Grading & Sorting	14 bags/ha	16/bag	₹224	₹224
Total FL			**₹20,524**	**₹20,524**
Capital/Fixed Investment				
Land lease rental	12,50,000 land cost per hectare	0.90% interest/month for 4 months	₹45,000	₹45,000
Tube well/farm pond/sprinkler	600,000 for 7 hectares land	0.90% per month for 4 months	₹3085	₹3085
Total Capital/Fixed Investment			**₹48,085**	**₹48,085**
Total cost A2 plus PL			**₹77,562**	**₹60,618**
Total C2 cost (A2 +FL+Fixed Cost)			**₹1,25,647**	**₹1,08,703**
Total Cumin Production	**7 quintals**	**24,000 /quintal as on 14 Feb 2024**	**₹1,68,000**	**₹1,68,000**
Total Income for the season (4 months)			**₹42,353 (₹10,588 per month)**	**₹59,297 (₹ 14,824 per month)**