Research Review

© 2025, Centre for Advanced Research in Agricultural Sciences
Research Journal of Agricultural Sciences
Volume 16; Issue 03 (May–Jun 2025); pp 267–276

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Black Cumin (*Bunium persicum* Bioss.): A Unique Treasure

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Received: 15 Feb 2025; Revised accepted: 01 May 2025

Abstract

Black Cumin (Kaala Zeera), scientifically known as *Bunium persicum*, is a high-value medicinal and culinary spice with deep cultural roots and growing global significance. This investigation explores the unique agronomic, economic, and therapeutic dimensions of Kaala Zeera, with a particular focus on its cultivation in the Gurez Valley of Jammu and Kashmir. The valley's high-altitude climate and traditional farming practices yield a distinctive variety of this spice, prized for its rich aroma and organic purity. Beyond its culinary appeal, Kaala Zeera possesses powerful medicinal properties, including antioxidant, anti-inflammatory, and antimicrobial effects, making it a staple in traditional medicine systems such as Ayurveda. Government initiatives under the Holistic Agriculture Development Programme (HADP), along with pioneering research by SKUAST-Kashmir, are revitalizing its cultivation and expanding its reach to new regions like Pulwama. These efforts not only aim to boost farmer incomes and conserve genetic diversity but also position Kaala Zeera as a sustainable and profitable crop for high-altitude agriculture. As global interest in natural remedies and organic produce increases, Kaala Zeera emerges as a symbol of heritage, health, and hope for the farming communities of Jammu and Kashmir.

***Key words*:** *Bunium persicum*, Treasure, Health benefits, Cultivation, Medicinal herb,

In the high altitudes of the Himalayas, where snow-fed rivers carve through ancient valleys and tradition intertwines with nature, thrives a spice as rare as it is remarkable—Kaala Zeera, or Black Cumin (*Bunium persicum*). Unlike its more familiar counterpart, common cumin, Kaala Zeera is a lesser-known but highly prized seed, celebrated for its complex flavor, potent medicinal qualities, and deep cultural roots [1]. From the terraced fields of Kashmir's Gurez Valley to ancient medicinal systems across Central and South Asia, black cumin (Kala zeera) has stood the test of time as both a culinary treasure and a therapeutic powerhouse [2]. This investigation delves into the multifaceted world of Kaala Zeera—exploring its botanical characteristics, ecological niche, methods of propagation, phytochemical richness, and vast array of health benefits [3-5]. At the heart of this study lies the Gurez Valley, a remote yet vital cradle of black cumin (Kala zeera) cultivation, where traditional farming practices and challenging climatic conditions yield one of the purest and most aromatic varieties in the world. Beyond its use in local cuisines and rituals, this spice holds significant economic and therapeutic potential, particularly in the context of growing global interest in herbal remedies and sustainable agriculture [6-7].

As modern science begins to validate what traditional wisdom has long held true, Kaala Zeera is emerging not just as a spice, but as a symbol of resilience, biodiversity, and rural innovation. With government support, academic involvement, and community-led efforts, this humble seed may very well be a catalyst for agricultural transformation in the Himalayan region—and a potent reminder of the value that lies in preserving and promoting our indigenous resources [8-9].

Biology

Black cumin (Kala Zeera), scientifically known as *Bunium persicum*, is a perennial herbaceous plant belonging to the family Apiaceae (previously known as Umbelliferae), commonly referred to as the parsley or carrot family [10]. It is a highly valued medicinal and aromatic plant, known for its pungent, piney, and slightly bitter seeds, which are widely used for both culinary and therapeutic purposes.

Taxonomy and distribution

Family	:	*Apiaceae*
Genus	:	*Bunium*
Species	:	*Bunium persicum*
Chromosome Number	:	2n = 14

Black cumin (Kala zeera) is native to Central Asia and is predominantly found in the high-altitude regions of the Himalayas, including northern India [11]. It thrives best in cool, temperate climates and well-drained soils of mountainous terrain [12].

Botanical characteristics

Bunium persicum exhibits the following morphological and botanical traits:

Growth habit: A tuberous, perennial herb, varying in height from 30 cm (dwarf) to 80 cm (tall). Plant types range from compact to spreading and are moderately to highly branched [13].

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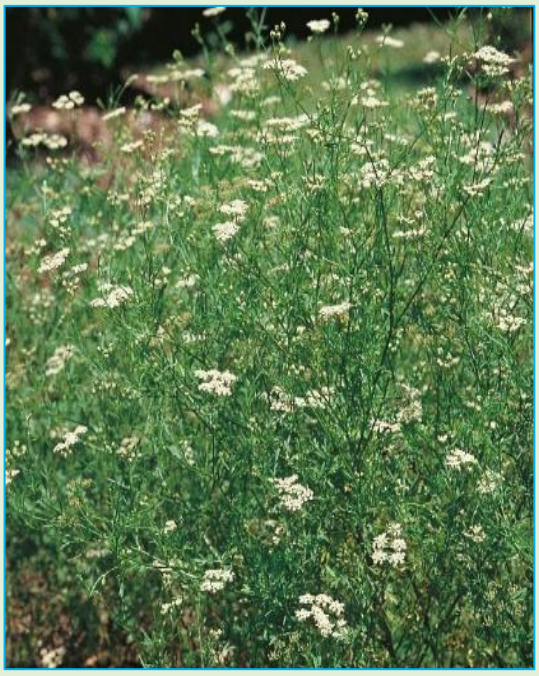
Citation: Shah AA. 2025. Black cumin (*Bunium persicum* Bioss.): A unique treasure. *Res. Jr. Agril. Sci.* 16(3): 267-276.

Propagation: Reproduces both sexually (via seeds) and asexually (via underground tubers). Sexual reproduction through seeds and asexual reproduction through underground tubers. This dual reproductive strategy contributes significantly to its adaptability and long-term survival in dry temperate regions [14].

Sexual reproduction occurs via seeds produced by mature plants. After flowering and pollination, the plant sets seeds, which can be harvested and sown to raise new plants. This method is crucial for large-scale cultivation, genetic diversity, and adaptation to environmental conditions. However, it requires more time for the plant to mature, typically taking up to 3–4 years to start yielding significant produce. Seed propagation also demands careful selection of healthy, viable seeds and optimal soil conditions to ensure good germination rates [15].

In addition to seed propagation, Black cumin (Kala Zeera) also reproduces asexually through underground tubers, which are small, swollen root-like structures. These tubers serve as storage organs and help the plant survive harsh climatic conditions. When planted, each tuber can give rise to a new plant, maintaining the genetic identity of the parent plant. Asexual propagation is faster and more reliable in terms of maintaining uniformity in desirable traits like flavor, yield, and resistance to local pests or diseases. It is particularly useful for conserving elite genotypes and establishing plantations with consistent quality [16]. Together, these two propagation methods make Kaala Zeera a resilient and sustainable crop, well-suited for long-term cultivation in its native agro-climatic zones.



Plant: Kaala Zeera (*Bunium persicum* Bioss.)

Leaves: Pinnately compound (2-3 times), finely dissected, and filiform (thread-like), contributing to its delicate appearance [17].

Stem: Hollow internodal regions with secretory canals that contain ethereal oils and resins, contributing to the plant's characteristic aroma [18].

Inflorescence: The plant produces umbel-type flower clusters, which are a defining feature of the Apiaceae family. Umbels are typically compact, borne on lateral and terminal branches, and appear from the third year of growth [19].

Flowers: Small, white, and symmetrical with five sepals, petals, and stamens. The bracts are linear and sometimes divided, while bracteoles are absent. Flowers have asymmetrical rays [20].

Gynoecium: Bicarpellate, with an inferior ovary and two styles fused at the base [21].

Fruit: A schizocarp, which splits into two mericarps attached to a central stalk (carpophore). The fruits contain characteristic oil canals (vittae) that are either globular or elongated [22].

Seeds: Small and aromatic; 1,000 seed weight is approximately 2 grams [23].

Tubers: Derived from hypocotyl or root origin, they act as storage organs and aid in asexual propagation [24].

Tubers: Black cumin (Kaala Zeera)

Seeds: Black cumin (Kaala Zeera)

Ecological and Economic Importance

Black cumin (Kala Zeera) is not only prized for its seeds and essential oil but also holds a significant place in traditional medicine for its digestive, carminative, and antimicrobial properties. Its cultivation supports livelihoods in mountainous regions, particularly in Jammu and Kashmir, Himachal Pradesh, and parts of Uttarakhand [25-27].

Black cumin (*Bunium persicum* Bioss.) in bloom

A Himalayan treasure: Cultivation in Gurez Valley

While its cultivation is widespread across the world, in the Indian subcontinent, the spice is predominantly found in this small, picturesque region. The Gurez Valley, nestled in the northernmost part of Jammu and Kashmir, holds the distinction of being one of the few areas where black cumin (Kala Zeera) is cultivated, making it a crucial part of the region's agricultural identity and economy. The Gurez Valley is located near the Line of Control (LoC) with Pakistan, offering an idyllic yet challenging environment for farming. It sits at an altitude of approximately 8,000 feet, surrounded by snow-capped mountains, dense forests, and swift-flowing rivers. The climate here is cool, with harsh winters and mild summers, providing a natural habitat for Kaala Zeera, a crop that thrives in temperate conditions. The valley's cool temperatures and well-drained soils create the perfect environment for the spice, giving it a distinctive flavor profile that is highly sought after. Unlike other regions where the cultivation of Kaala Zeera is done primarily for commercial farming, the Gurez Valley has a unique connection to this crop, rooted in centuries-old agricultural practices. The farmers in the region cultivate Kaala Zeera primarily on terraced fields, which are irrigated using mountain springs and streams. This traditional farming method ensures that the crop remains free from industrial pollutants and pesticides, making the Gurez Valley's Kaala Zeera particularly organic and aromatic [28-30].

The cultivation of Black cumin (Kala Zeera) in Gurez Valley is more than just an economic activity; it holds cultural and historical significance for the local communities. Historically, the region has been home to a diverse population of Kashmiris and other indigenous groups, who have passed down farming knowledge through generations. The cultivation of this prized spice is an important part of the agricultural calendar, and its harvest is seen as an event of considerable importance in local culture. Kaala Zeera plays a pivotal role in the local diet. It is used in traditional Kashmiri cuisine, contributing depth and a distinct flavor to various dishes. From stews to rice dishes, the spice is an integral part of the flavorsome Kashmiri palette. During festivals and religious ceremonies, the spice is often incorporated into foods to bring out the aromatic richness of the cuisine. Furthermore, the cultivation of Black cumin (Kala Zeera) is not limited to local use. Its demand has steadily increased due to its medicinal properties and its popularity among food enthusiasts. As a result, it has become a valuable crop for farmers in the region, providing an alternative income stream amidst the challenges of agricultural life in high-altitude areas [31].

Method of sowing

Black cumin (Kala zeera) can be propagated either through seed sowing or by replanting rootstocks (bulbs) from the previous year. Black cumin (*Bunium persicum*), can be propagated using two primary methods: seed sowing and vegetative propagation through rootstocks. In the seed sowing method, mature seeds collected from previous harvests are directly sown into prepared fields, usually during the appropriate planting season [32]. This method is commonly used for large-scale cultivation and ensures genetic diversity in the crop. However, seed germination can be slow and requires specific temperature and moisture conditions for optimal success. Alternatively, black cumin (Kala Zeera) can be propagated by replanting rootstocks or bulbs (also referred to as tuberous roots) that were harvested in the previous growing season. These bulbs are stored and then replanted in the next season. This method, often preferred in traditional or small-scale farming, can lead to faster establishment and uniform growth since the plants are already partially developed [33]. It also helps preserve specific plant traits, making it a reliable option for maintaining the quality and consistency of the crop [34].

Time of Sowing: Seed sowing is commonly practiced during the months of October to November. There are three main methods used for seed sowing:

Broadcasting method: In this method, seeds are scattered evenly over the field at the rate of approximately 1.5 kg/ha.

Seed drill method: A seed drill ensures uniform placement of seeds at the desired depth and spacing.

Line sowing: This method involves sowing seeds in rows, maintaining an inter-row spacing of 30 cm, 40 cm, or 50 cm depending on field conditions and agronomic practices. Seeds are sown at a depth of about 2 cm. After about 20 days of sowing, thinning is carried out to maintain a distance of 20 cm between plants, ensuring proper growth space and air circulation [35].

Bulb sowing (Rootstock planting)

Propagation using bulbs (rootstocks from the previous year) is also practiced. This method is effective when the soil moisture content is favorable for deep ploughing, meaning the field is neither too wet nor too dry. Proper soil preparation is essential for good root development and plant establishment [36].

Phytochemical composition of black cumin

The therapeutic potential of black cumin is largely attributed to its rich and diverse phytochemical profile. Among the various compounds present in its seeds, the most studied and bioactive is thymoquinone (TQ). This compound forms the cornerstone of many of black cumin's health benefits, especially due to its strong antioxidant and anti-inflammatory properties.

1. *Thymoquinone (TQ)*

Thymoquinone is a monoterpene with well-established pharmacological actions. It acts as a powerful free radical scavenger, neutralizing reactive oxygen species (ROS) that cause oxidative damage to cells and tissues. Its anti-inflammatory effect works by downregulating inflammatory cytokines and inhibiting pathways like NF-κB, which are commonly associated with chronic diseases such as diabetes and neurodegeneration. TQ also plays a role in modulating glucose metabolism, making it highly relevant in diabetes management [37-39].

2. *Alkaloids*

Alkaloids are nitrogen-containing compounds known for their pharmacological activity. In black cumin, alkaloids such as nigellicine and nigellidine contribute to its neuroprotective, antioxidant, and analgesic effects. These compounds also help in regulating blood pressure and enhancing metabolic functions, which may assist in reducing the complications associated with diabetes and cardiovascular disease [40].

3. *Saponins*

Saponins are glycosidic compounds known for their immune-boosting, antimicrobial, and cholesterol-lowering properties. In black cumin, they aid in regulating lipid profiles, potentially reducing LDL cholesterol and triglycerides. Since dyslipidemia is a common comorbidity in diabetes, this lipid-regulating function is particularly beneficial. Saponins also exhibit anti-cancer and detoxifying actions, enhancing the overall protective effects of black cumin [41].

4. *Essential oils*

Black cumin seeds are rich in volatile oils, including:

- p-Cymene
- Carvacrol
- α-Pinene
- t-Anethole

These essential oils exhibit antibacterial, antifungal, and antioxidant activities. Carvacrol and p-cymene, in particular, have been studied for their role in reducing inflammation and microbial infections, while also supporting gastrointestinal health. These oils contribute not only to the medicinal value but also to the aromatic and preservative properties of black cumin [42].

5. *Vitamins*

Black cumin is a source of fat-soluble vitamins, especially vitamin E (tocopherols). Vitamin E is a potent lipid-soluble antioxidant that helps maintain the integrity of cellular membranes, prevents oxidative damage, and supports skin health. Its role in preventing oxidative stress is crucial for anti-aging effects and in protecting organs from diabetic complications like nephropathy and retinopathy [43].

6. *Polyunsaturated fatty acids (PUFAs)*

The oil extracted from black cumin seeds contains significant levels of linoleic acid (omega-6) and other essential fatty acids. These contribute to heart health, cell membrane integrity, and anti-inflammatory responses. PUFAs also support brain function and reduce insulin resistance, making them beneficial in managing diabetes and preventing cognitive decline with age.

Synergistic effects

What makes black cumin particularly potent is the synergistic interaction of these compounds. Rather than acting in isolation, these bioactives work together to:

- Reduce oxidative stress
- Improve glucose metabolism
- Protect vital organs from damage
- Strengthen the immune system
- Slow down degenerative processes associated with aging

This multi-targeted action is especially valuable in chronic, complex conditions like diabetes and aging, where multiple physiological systems are involved. Such a broad-spectrum effect also supports the traditional use of black cumin in holistic and integrative medicine [44-45].

A powerful medicinal herb

Beyond its culinary uses, black cumin (Kala Zeera) has been revered in traditional medicine for thousands of years. The seeds contain a compound called thymoquinone, which has powerful antioxidant, anti-inflammatory, and antimicrobial properties [46]. This makes it a staple in natural healing practices around the world. In Ayurveda, the ancient Indian system of medicine, Kaala Zeera is used to treat a variety of ailments, including digestive issues, asthma, and skin conditions. It is believed to improve digestion, boost the immune system, and even reduce blood sugar levels [47-50]. In some parts of the world, the seeds are ground into a paste or brewed as a tea to treat ailments ranging from headaches to coughs. One of the most notable uses of Kaala Zeera in modern medicine is its potential role in promoting heart health. Studies have suggested that it may help lower blood pressure and cholesterol, making it a valuable addition to any heart-healthy diet. Some research also points to its potential anti-cancer properties, though more studies are needed to confirm these findings [51].

Ancient wisdom meets modern science

Despite its ancient origins, black cumin (Kala Zeera) is gaining renewed attention in the world of modern science and wellness. As more people seek natural alternatives to pharmaceutical solutions, the demand for plant-based remedies like Kaala Zeera is growing. Health-conscious individuals are increasingly turning to this humble seed, not only for its culinary benefits but also for its medicinal potential. Researchers are continuing to study the numerous health benefits of Kaala Zeera, with promising results pointing to its ability to alleviate symptoms of chronic conditions such as arthritis, diabetes, and high cholesterol. The growing body of evidence suggests that Kaala Zeera's therapeutic properties could offer a more natural approach to managing some of today's most common health concerns.

In recent years, there has been a growing recognition of the medicinal benefits of black cumin (Kala Zeera), further boosting its demand in both national and international markets. The seeds of *Nigella sativa* are rich in thymoquinone, an active compound known for its antioxidant, anti-inflammatory, and antimicrobial properties [52]. Research has shown that Kaala Zeera may offer a range of health benefits, from boosting the immune system to managing conditions like diabetes, asthma, and even high blood pressure. As global interest in herbal and natural remedies grows, the demand for organic and high-quality Kaala Zeera from Gurez has also increased. This has opened up opportunities for local farmers to tap into international markets, especially in the Middle East, Europe, and parts of Asia. The export potential of Gurez Valley's Kaala Zeera is promising, though it is often limited by logistical and security challenges [53].

Anti-diabetic properties

Black cumin is a plant widely used in traditional medicine for its therapeutic benefits. It contains a variety of bioactive compounds, with thymoquinone (TQ) being the most prominent. These components contribute to its antioxidant, anti-inflammatory, anti-diabetic, and anti-aging properties. One of the key medicinal properties of black cumin lies in its ability to help manage diabetes. It works by reducing blood sugar levels, improving insulin sensitivity, and protecting pancreatic beta cells [54]. It also helps lower oxidative stress, which is often elevated in people with diabetes and is a major contributor to long-term complications such as nerve damage, kidney problems, and eye disorders. In terms of anti-aging, black cumin fights free radicals through its antioxidant activity. This helps reduce cellular damage and supports healthier aging. Its anti-inflammatory effects also slow down the progression of age-related diseases by reducing chronic, low-grade inflammation—a common underlying cause of many degenerative conditions. The combined effect of antioxidant protection, glucose regulation, and cellular repair mechanisms makes black cumin a promising natural remedy for both diabetes management and healthy aging. However, while traditional use and early studies are encouraging, more scientific research and clinical trials are needed to fully confirm its long-term effectiveness and safety in modern medicine [55-56].

Clinical and therapeutic implications

Given its broad pharmacological profile, black cumin is a promising nutraceutical for managing chronic diseases. Its use as a complementary therapy alongside conventional diabetes treatment could improve outcomes and reduce drug dependency [57]. Additionally, its protective effects on tissues and organs make it a potential anti-aging supplement. However, while promising, these benefits must be verified by large-scale human trials, standardization of doses, and long-term safety assessments.

A flavorful addition to the pantry

Black cumin (Kala Zeera) might look similar to its more widely recognized cousin, regular cumin, but its flavor is far more complex. The seeds are black and smaller than regular cumin, with a unique combination of flavors that include earthy, nutty, and slightly bitter notes. This makes black cumin (Kala Zeera) an excellent addition to a variety of dishes. In Indian cuisine, it is often used in spice blends like garam masala, and its flavor pairs wonderfully with lentils, rice, and roasted vegetables. It's also a staple in Middle Eastern and Mediterranean cooking, where it adds depth to stews, meat dishes, and breads. The beauty of black cumin (Kala Zeera) lies in its ability to enhance both vegetarian and non-vegetarian dishes. In some regional recipes, Kaala Zeera is fried in ghee or oil at the beginning of cooking to release its aroma and essential oils, adding an extra layer of complexity to the dish. It is also commonly sprinkled on top of flatbreads, such as naan or paratha, before baking [58-59].

Uses of black cumin (Kala Zeera) *at home*

For those interested in incorporating black cumin (Kala Zeera) into their daily lives, there are many simple and effective ways to do so. The seeds can be easily added to spice blends, such as curry powders, or simply sprinkled over salads and roasted vegetables. Some people like to brew Kaala Zeera into a tea, which is thought to help with digestion and detoxification. Another popular way to consume Kaala Zeera is through oil, which is extracted from the seeds and can be used for both culinary purposes and skincare. The oil is sometimes used to treat skin conditions like eczema or acne, as its antimicrobial properties can help soothe inflammation and promote healing. Whether you're a home cook looking to add an exciting new flavor to your dishes or someone seeking natural remedies for common ailments, Kaala Zeera offers a wealth of possibilities. Its rich flavor and powerful medicinal properties make it a true hidden gem in both the culinary world and the world of wellness. As interest in herbal remedies and natural ingredients continues to rise, it's likely that Kaala Zeera will continue to find its place in kitchens and medicine cabinets around the world. Its legacy as both a spice and a healing herb is a testament to the timeless wisdom of ancient cultures—and it's a reminder that sometimes, the smallest of seeds can have the greatest impact [60-62].

Government support and subsidy initiatives

Recognizing the economic and cultural value of black cumin (Kala Zeera), the government has taken significant steps to support its cultivation, particularly under the Holistic Agriculture Development Programme (HADP). One of the key initiatives includes providing an 80 percent subsidy to farmers who establish nurseries for Kaala Zeera across various districts of the Kashmir Valley. This subsidy not only incentivizes the cultivation of this niche crop but also aims to improve production quality, create livelihood opportunities, and reduce dependency on traditional, less profitable crops. By encouraging the propagation of Kaala Zeera through well-supported nurseries, the program fosters sustainable agricultural practices and boosts the overall economic resilience of farming communities in the region.

The Gurez Valley's Kaala Zeera is more than just a spice; it is a symbol of the region's agricultural heritage, resilience, and potential. Its unique growing conditions and the traditional farming methods used in its cultivation make it a highly sought-after product. As global interest in natural health remedies and organic foods continues to rise, the demand for this exceptional spice will likely grow, offering new opportunities for the farmers of Gurez Valley. However, for Kaala Zeera cultivation to truly flourish, there must be continued investment in infrastructure, market access, and farmer support. With the right policies in place, the Gurez Valley could become a global hub for the production of this medicinal and culinary treasure—helping to preserve its unique agricultural traditions while fostering sustainable economic growth for generations to come.

To address the challenges faced by farmers in Gurez Valley, there has been an increasing push from both state and central governments to promote sustainable agricultural

practices and improve infrastructure in the region. The introduction of programs aimed at enhancing irrigation systems, improving road access, and providing farmers with modern tools and techniques can help improve the yield and quality of Kaala Zeera crops. Moreover, the government has also been exploring avenues for organic certification of Kaala Zeera from Gurez Valley. If successful, this could increase its value and appeal in international markets. Organic certification would not only help local farmers secure better prices for their crops but also elevate the region's standing as a producer of high-quality, environmentally sustainable agricultural products.

SKUAST-Kashmir initiative

Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir (SKUAST-K), launched a groundbreaking initiative to introduce Kala Zeera (Black Cumin) cultivation to farmers across the Kashmir Valley, particularly focusing on the saffron growing areas of Pulwama district. This move aims to revolutionize farming practices and enhance economic prospects in the region. Traditionally, the cultivation of Black Cumin was confined to high-altitude forested areas such as Gurez and Paddar, where it grew naturally. However, overexploitation in these areas had pushed the crop to the brink of extinction. Recognizing the potential of this high-value spice, SKUAST-Kasmir undertook significant efforts to conserve its genetic resources. The university preserved the seeds and began multiplying corms for distribution in other suitable agro-climatic zones [63].

To assess the crop's adaptability, SKUAST-Kasmir collected 80 different selections from across Kashmir. After comprehensive trials and evaluations, four genotypes emerged as highly promising for broader cultivation. Plans are now underway to expand their growth, particularly around the saffron-rich belts near the university's Research Station in Dusso, Pampore. A key component of the initiative involves engaging progressive farmers and raising awareness about the scientific cultivation of Black Cumin. Previously, farmers had limited knowledge of this crop, despite its remarkable economic potential. Estimates suggest that from one Kanal (0.05 hectares) of land, around 18 kilograms of Black Cumin can be harvested, with each kilogram valued at around Rs. 6,000—offering a potential income of nearly Rs. 1.0 Lac per Kanal.

Moreover, Black Cumin is highly compatible with saffron cultivation, a major advantage for the region. It can be intercropped with saffron without affecting the latter's yield. While Black Cumin is harvested in May and June, saffron is harvested in October, allowing both crops to thrive in the same field without conflict. By introducing Black Cumin as a viable and profitable cash crop, SKUAST-Kashmir aims to significantly uplift the economic conditions of farmers and promote sustainable agriculture in Pulwama and beyond. This initiative holds the promise of diversifying the region's agricultural portfolio and ensuring long-term resilience for its farming community.

Black cumin (Kala Zeera) is more than a spice, it is a symbol of heritage, health, and hope for the farming communities of Jammu and Kashmir, especially in the Gurez Valley. With its unmatched culinary richness and proven medicinal value, this small seed holds immense potential for local livelihoods and global markets alike. As government support and scientific interest grow, Kaala Zeera stands poised to become not only a staple in kitchens and medicine cabinets, but also a catalyst for sustainable development in high-altitude farming regions. With continued investment, awareness, and innovation, this unique treasure can truly flourish, bridging ancient wisdom with modern opportunity [64].

Economics

The economic viability of Black cumin (*Bunium persicum*) cultivation in high-altitude, dry temperate regions of Kashmir has shown promising potential due to its high market value, low input requirements, and suitability to the region's agro-climatic conditions. Here's a detailed look at its economic feasibility:

Agro-climatic suitability

Altitude: 1800–2700 meters above mean sea level (ideal for parts of Kupwara, Pulwama, Kulgam, Anantnag, Gurez, and upper belts of Baramulla).

Climate: Prefers cold winters (for vernalization) and moderately dry summers.

Soil: Well-drained sandy loam with neutral to slightly alkaline pH is optimal.

Economic aspects

A. *Cost of cultivation (per kanal)*

Table 1 Economic aspects: Cost of cultivation (per kanal)

Component	Approx. Cost (INR)
Seed (1–1.5 kg @ ₹4000–₹6000/kg)	₹5000 – ₹7000
Land preparation & sowing	₹2000
FYM + fertilizers	₹1000
Irrigation (if needed)	₹500
Weeding & interculture (2 times)	₹1500
Harvesting and drying	₹1500
Miscellaneous (transport, storage)	₹500
Total	₹12,000 – ₹14,000

The data depicted in (Table 1) presents a detailed breakdown of the approximate costs involved in cultivating a crop on one kanal of land, with the total estimated cost ranging from ₹12,000 to ₹14,000. The most significant expense is the seed cost, varying from ₹5000 to ₹7000 depending on the quantity used (1–1.5 kg) and the price per kilogram (₹4000–₹6000/kg). Land preparation and sowing cost ₹2000, while FYM (Farm Yard Manure) and fertilizers add ₹1000. If irrigation is needed, it adds ₹500 to the total. Weeding and interculture operations, done twice, cost around ₹1500. Harvesting and drying the crop also require ₹1500, and miscellaneous expenses such as transportation and storage contribute an additional ₹500. This comprehensive cost estimate helps in understanding the financial inputs required for small-scale crop cultivation [65]. The table provides a clear and concise overview of the key cost components associated with cultivating a crop on a per-kanal basis, highlighting seed cost as the major contributor. It serves as a useful reference for farmers and planners to estimate input requirements and make informed decisions for efficient resource allocation and budgeting.

B. *Yield*

- Initial yield starts low in the first 2–3 years (0.3–0.5 kg/kanal), but increases to 1–1.5 kg/kanal by the 4th or 5th year.
- Kala Zeera is a long-gestation crop (full commercial yield after 3 years).

C. *Market price*

Ranges from ₹5000 to ₹10,000/kg depending on purity, demand, and market channels (domestic/export).

The market price of black cumin (Kala Zeera) can fluctuate significantly, ranging from ₹5000 to ₹10,000 per kilogram, influenced by a variety of factors such as the purity of the product, market demand, and the specific market channels through which it is sold (domestic or export). Purity plays a crucial role in determining the price. Higher-quality Black Cumin, which is free from contaminants and has a high concentration of essential oils (the primary valuable compound), commands a premium price. Purity is often determined through careful harvesting, cleaning, and processing methods that ensure minimal foreign matter, moisture content, and pesticide residue. As the essential oils in Black Cumin are prized for their medicinal and culinary properties, purer forms of the spice, such as those with a higher percentage of these oils, can fetch prices at the higher end of the spectrum, closer to ₹10,000 per kg [66].

Market demand is another significant determinant. In regions where Black Cumin is used extensively for culinary, medicinal, or cosmetic purposes—such as in the Middle East, parts of Asia, and increasingly in Western markets—demand can drive prices higher. As awareness of its health benefits grows, such as its use as an anti-inflammatory, antioxidant, and digestive aid, demand in both domestic and international markets may increase, pushing prices upwards. The market channel also plays a key role. Domestic demand for Black Cumin tends to keep prices relatively stable, but export markets can significantly influence prices. For example, countries like Saudi Arabia, Egypt, and others in the Middle East, along with European countries, are major importers, and the demand for Kaala Zeera in these regions can increase the price, especially when the product is of high quality. The export market typically offers higher prices due to added costs such as transportation, tariffs, and the necessity for packaging to meet international standards, further raising the market price [67].

Seasonal factors can also impact pricing. For instance, during harvest seasons when supply is abundant, prices may dip, while during off-seasons when supply is lower, prices may rise. Furthermore, variations in weather conditions, such as droughts or floods, can affect the harvest and availability, creating temporary imbalances in supply and demand that can drive prices up or down. Overall, the price range of ₹5000 to ₹10,000 per kilogram of Black Cumin reflects its diverse uses, the varying quality of the product, and the balance between supply and demand within both domestic and international markets [68].

D. *Revenue*

Conservative estimate (after 4th year):

→ 1 kg x ₹7000 = ₹7000/kanal
→ Net return = ₹7000 – ₹13,000 = Loss initially, but

Cumulative return (year 4–10, without replanting):

→ Average of 1 kg/year = ₹7000/year for 7 years
→ Total = ₹49,000
→ Net profit over 10 years = ₹49,000 – ₹13,000
= ₹36,000 profit per kanal

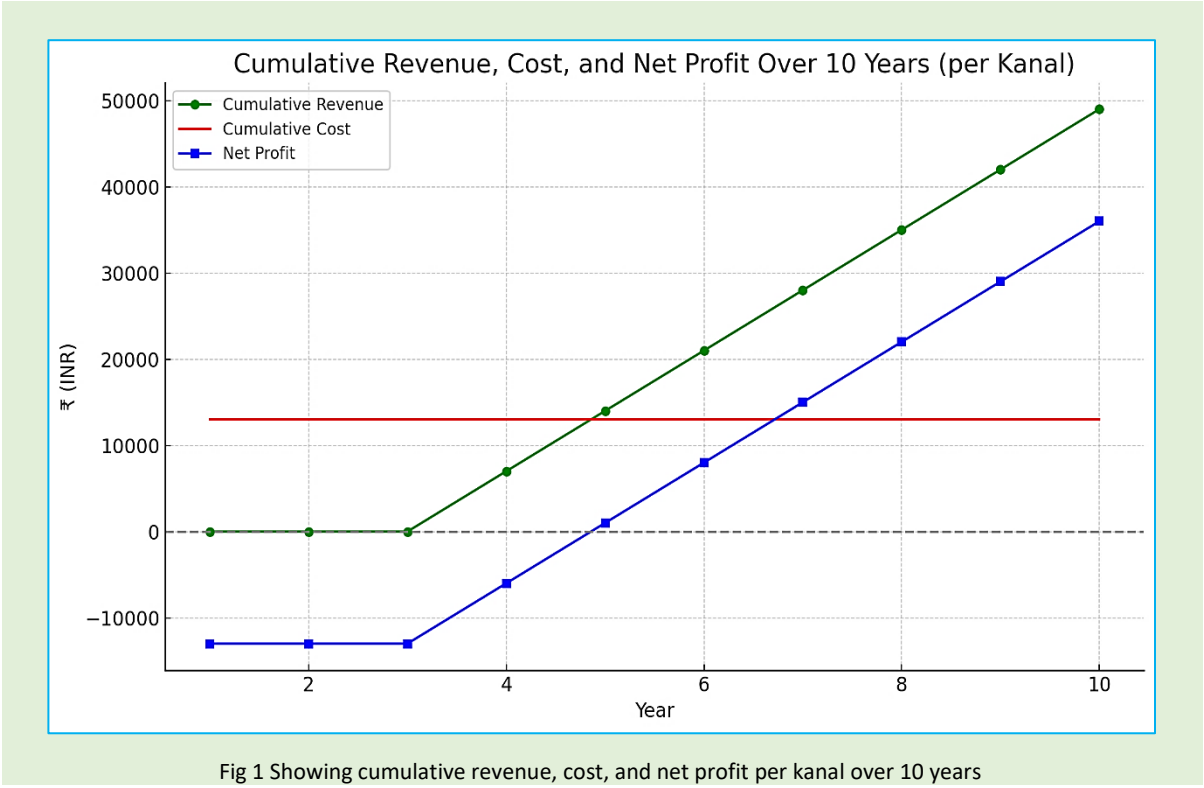


Fig 1 Showing cumulative revenue, cost, and net profit per kanal over 10 years

Black cumin (Kala Zeera) cultivation, though initially involving a one-time investment of ₹13,000 per kanal, becomes profitable starting from the fourth year onward, as the plant begins to yield effectively. With a conservative estimate of 1 kg yield per kanal annually and a market rate of ₹7000 per kg, the annual income from the fourth year is projected to be ₹7000. Since Kalazeera is a perennial plant, it does not require replanting, allowing it to continue producing for at least seven more years without additional major expenses. Over the 7-year period (years 4 to 10), the cumulative income amounts to ₹49,000 per kanal. After deducting the initial investment, the net profit over ten years stands at ₹36,000 per kanal. Although the initial years may reflect a loss due to the absence of returns, the long-term gains underscore the crop's economic viability and sustainability [69].

Economic viability indicators

The (Table 2) presents key financial indicators for evaluating the economic viability of a cultivation project. The Benefit-Cost Ratio, recorded at approximately 2.5:1 after the

third year, indicates that for every ₹1 invested, there is a return of ₹2.50, showcasing strong profitability over time. The Payback Period is estimated to be 3 to 4 years, suggesting that the initial investment can be recovered within this timeframe [70]. An Internal Rate of Return (IRR) of over 20% reflects a highly attractive return on investment, surpassing typical benchmark rates. Furthermore, the Net Present Value (NPV) is noted as positive in the long term, implying that the project is expected to generate more value than its cost when future cash flows are discounted. The financial indicators suggest that the cultivation project is economically viable and profitable in the long term, with a high benefit-cost ratio, a reasonable payback period, a strong IRR exceeding 20%, and a positive NPV.

Table 2 Economic viability of a cultivation of black cumin

Parameter	Value
Benefit-Cost Ratio (after 3rd year)	~2.5:1
Payback Period	3–4 years
Internal Rate of Return (IRR)	>20%
Net Present Value (NPV)	Positive (long term)

Challenges

- Long gestation period.
- Susceptibility to rodents and poor seedling establishment.
- Labor-intensive harvesting.
- Limited awareness about agronomic practices and value addition.

Recommendations

- Promote through FPOs and SHGs for aggregation and collective marketing.
- Nursery development support for quality seedling production.
- Government incentives under Holistic Agriculture Development Programme (HADP), MIDH, or integrated high-value crop missions.
- Value addition through branding, packaging, and export facilitation.
- Possible intercropping with saffron, peas or pulses in early years.

CONCLUSION

Black cumin (Kaala zeera), stands as a remarkable convergence of tradition, nutrition, and economic opportunity. Native to the high altitudes of Jammu and Kashmir—particularly the Gurez Valley—this spice embodies not only the biodiversity of the region but also the deep-rooted cultural practices of its people. With its unique flavor, organic purity, and medicinal power, Kaala Zeera holds immense value in both domestic and international markets. Government-led initiatives, such as those under the Holistic Agriculture Development Programme (HADP), alongside the pioneering efforts of SKUAST-Kashmir, are breathing new life into its cultivation, helping farmers transition to more sustainable and profitable models of agriculture. As scientific research continues to validate its health benefits and consumer interest in natural, organic products rises globally, Kaala Zeera is poised to transform from a hidden Himalayan gem into a globally recognized symbol of health, heritage, and high-altitude agricultural excellence. Its success story offers a blueprint for how traditional crops, when nurtured through innovation and policy support, can serve as powerful engines of rural resilience and economic renewal.

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