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Quantitative Insights into Breeder Seed Production trends and Varietal Adoption in Major Seed Spices

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Abstract

This study presents a comprehensive analysis of breeder seed (BS), indent, allocation and production of seed spices over a ten-year period (2015–16 to 2023–24) to assess the efficiency and future scope of the formal seed system in India. The findings reveals that only three seed spices viz., cumin, coriander, and fenugreek consistently received breeder seed indents for further multiplication. The number of varieties from seed spices entering into seed chain were also less as 29 varieties in coriander, 19 varieties in fenugreek and 2 varieties in cumin received BS indent in last decade. The seed spices varieties viz., GC-4 in cumin, RCR-436 and RCR-435 in coriander, and RMt-1 and RMt-305 in fenugreek are dominated in BS indents and production, indicating their strong farmer preference and agronomic suitability. Institutionally, research centers like RARI, Durgapura and ICAR-NRCSS, Ajmer emerged as major contributors to varietal development and seed multiplication. However, limited participation from other breeding centers underscores the need for broader inclusion and capacity enhancement across regions. The analysis also revealed crop-specific variation in BS indent sources. While cumin's BS demand was entirely met by public sector agencies, coriander and fenugreek showed growing involvement from private seed companies, which accounted for 24% and 22% of total indents, respectively. Projections for certified seed production in 2025–26, based on seed rate, SMR, and area under cultivation, indicated an SRR ranging from 5.27% in cumin and 7.87% in fenugreek to 48.16% in coriander, considering the seed chain alone. However, to obtain a clearer picture, the contribution of the private sector into the formal seed supply system, needs to be accounted. The study emphasizes the need for enhancing varietal diversification, strengthening public–private partnerships, and aligning breeder seed production more closely with state-wise demand forecast to ensure sufficient availability of quality seeds of seed spice crops.

Keywords: Breeder seed, Seed Spices, Cumin, Coriander, Fenugreek, Seed Multiplication Chain

Introduction

Seed spices grown in India's arid and semi-arid regions are in high domestic and global demand due to their culinary, medicinal, and industrial uses. India leads the world in seed spice production, consumption, and export, accounting for over 80% of global output and area. Rajasthan and Gujarat, contributing more than 80% of seed spice area, are known as the "Seed Spices Bowl of India." Seed spices cover 47% of India's total spice area and contribute 19.5% to its spice production, with 24% exported to nearly 100 countries. In 2023–24, seed spices exports were 8143 crores, boosted by rising global demand and increased health awareness post-COVID-19 (Spices Board, 2023–24). Despite being important foreign exchanger crops, the productivity of seed spices varies across regions due various factors *viz.*, cultivation in low-fertility desert soils, high pest and disease incidence, and lack of quality planting material. Among them, limited availability of quality seed is the major concern as its importance is also mentioned in Manu Smriti, "*Subeejam Sukshetre Jayate Sampadyate*" meaning good seed in fertile land brings prosperity and quality seed alone can boost yields by 15–20%, and up to 45% with optimal management (Kumar *et al.*, 2021).

The limited availability of quality seed in seed spices is mainly due to inadequate varietal diversity, low awareness of improved varieties, poor seed production infrastructure, and limited awareness about quality seed. Most Indian seed spice farmers are smallholders growing under low-input conditions, relying on farm-saved seed, leading to low (<10%) seed replacement rates (SRR). The Indian seed spice sector faces challenges due to weak formal seed systems, limited involvement of reputed private companies, and heavy reliance on informal sources like farm-saved seeds (Kaundinya, 2025). This results in the spread of poor-quality or spurious seeds especially in cumin leading to low vigor, higher disease risk, excessive agrochemical use, and export rejections due to residue issues. In regions like western Rajasthan and northwest Gujarat, where over 80% of seed spices are cultivated, the absence of strong private sector engagement in seed multiplication further exacerbates the problem (Malhotra, 2016). Farmers often rely on locally marketed seed of unknown origin, which compromises

crop performance and export quality. The availability of good-quality seeds of high-yielding varieties with superior genetic purity is essential for high production under different agro-climatic conditions in any crop (Singh *et al.*, 2020). Breeder seed (BS), the first and genetically pure seed generation from nucleus seed, forms the backbone of quality seed production. In India, BS production is supervised by crop breeders and monitored annually through the breeder seed indent system managed by the Seed Division of the Department of Agriculture and Farmers Welfare (DA&FW). The AICRP-Spices network, in collaboration with SAUs, ensures varietal purity and breeder seed production. Despite the release of numerous seed spice varieties over the years, adoption and breeder seed production of these varieties remain limited. A consistent gap between breeder seed indents and actual production highlights issues like varietal mismatch, infrastructure constraints, limited state level multiplication, and weak policy support. Additionally, scattered and poorly documented data on breeder seed production and varietal trends hinder effective long-term planning and policy-making. In seed spices, only public sector-bred varieties come into the seed chain system for seed multiplication; however, the varieties developed by the private sector and notified through the Central Variety Release Committee (CVRC) do not proceed into the seed chain and sell their seeds directly to the farmers.

The present study aims to analyse breeder seed indent and production trends of key seed spice crops *viz.*, cumin, coriander, and fenugreek (from 2015–16 to 2023–24) while focusing on varietal seed chain, breeder seed indents & actual production, identifying top-performing varieties, and examining constraints in seed multiplication. The study highlighted a strategic roadmap to strengthen the breeder seed system, bridge seed gaps, maintain varietal purity, boost productivity, and support India's global leadership in seed spices.

Materials and Methods

Data Mining

Data related to breeder seed (BS) indent, allocation, and production of cumin, coriander, and fenugreek varieties were extracted from the Seednet India Portal. (Seednet, 2025). The data spanned 10 years (2015-16

to 2023-24), covering all breeder seed production centers across India under the National Seed Programme framework.

Seed Replacement Rate (SRR)

SRR indicates the extent to which quality seed of improved varieties is used to replace farm-saved seeds. SRR was estimated using the following formula:

$$SMR = \left(\frac{X}{Y} \right) \times 100$$

Where:

X = Quantity of quality seed used for sowing

Y = Quantity of seed required to cover the entire sown area with quality seed

Seed Multiplication Ratio (SMR)

SMR represents the number of seeds produced per unit seed sown and serves as a key indicator for planning seed production stages. For seed spices, the SMR was calculated for each crop using the formula:

$$SMR = \left(\frac{X}{Y} \right) \times 100$$

Where:

X = Pure seed yield (kg)

Y = Seed rate used (kg)

Projected Foundation and Certified Seed Production

The projected quantities of foundation and certified seeds were computed by multiplying breeder seed quantities with the respective SMRs for each seed stage. The calculations were done as follows:

Foundation Seed (q) = Breeder Seed (q) × SMR

Certified Seed (q) = Foundation Seed (q) × SMR

Projected Area Coverage Under Quality Seed

Based on the total available quality seed and standard seed rate, the potential area coverage under certified seed was estimated using:

Area Coverage (ha) = Total Quality Seed (kg) / Seed Rate (kg/ha)

Data Interpretation

All collected data were compiled, tabulated, and analysed using Microsoft Excel (2021 version). Trends in BS indent and production, variety wise contribution, and projected seed availability across the seed chain were visualized and interpreted to understand the dynamics of breeder seed production in seed spices.

Results and Discussion

The breeder seed (BS) data for coriander, cumin, and fenugreek presented from 2015–16 to 2023–24 provides critical insights into the seed supply chain of seed spices. This mechanism plays a pivotal role in ensuring availability of quality seed to meet the demands of the National Seed Plan under the Indian Seed System.

Number of varieties in seed chain

The retrospective analysis of breeder seed (BS) indents in seed spice crops revealed that indents were consistently received only for three major crops: cumin, coriander, and fenugreek. No breeder seed indents were recorded for the remaining seed spice crops during the study period (2015–16 to 2023–24), indicating limited varietal demand or integration into the formal seed chain for these crops. In cumin, BS indents were restricted to just two varieties Gujarat Cumin-4 (GC-4) and RZ-223 with GC-4 emerging as the dominant variety across the years. This variety, developed by the Seed Spices Research Station, SDAU, Jagudan, has demonstrated consistent performance and strong farmer preference, reflecting its relevance in commercial cultivation. Prolonged large-scale cultivation of same variety, narrows the genetic base, leads to susceptibility for evolving pests, diseases, and environmental stresses. Therefore, broadening genetic diversity through advanced breeding approaches is essential for enhancing resilience, adaptability, and sustainability in cumin. Coriander recorded the highest varietal diversity in breeder seed indents, with 29 different varieties entering the seed chain. Among these, RARI, Durgapura and ICAR-NRCSS, Ajmer played pivotal roles, each contributing four varieties. Similarly, in fenugreek, 19 varieties were included in the seed chain, again with RARI Durgapura and NRCSS Ajmer being the leading centres in varietal development.

The enduring popularity of certain older varieties, such as RCR-436 in coriander (released in 2005) and RMT-1 in fenugreek (released in 1991), both by RARI Durgapura, reflects their adaptability and continued farmer acceptance over time.

In addition to the major centres, several other institutions have made notable contributions to seed spices varieties development viz., CCSHAU, Hisar;

Table 1: A detailed description of the seed spices varieties in seed chain during last 10 years in India (2015-16 to 2023-24)

S.No.	Crop	Variety name	Parent institute	Release Year
Cumin Varieties				
1.	Cumin	Gujarat Cumin-4 (GC-4)	SSRS, Jagudan	2006
2.	Cumin	RZ-223 (UC-223)	RARI, Durgapura	2007
Coriander Varieties				
1.	Coriander	RCR-436	RARI, Durgapura	2005
2.	Coriander	RCR-435	RARI, Durgapura	2006
3.	Coriander	Hisar Sugandh (DH-36)	CCSHAU, Hisar	2006
4.	Coriander	CS 6	APHU, Lam, AP	-
5.	Coriander	CS-4	APHU, Lam, AP	-
6.	Coriander	RCr-728 (UD-728)	RARI Durgapura	2010
7.	Coriander	Pratap Raj Dhanian-1 (RKD- 18)	AU, Kota	2015
8.	Coriander	Punjab Suganda	PAU, Ludhiana	2015
9.	Coriander	Hisar Surabhi	HAU, Hisar	2006
10.	Coriander	Sugandha	HAU, Hisar	2005
11.	Coriander	Pant Haritma	GBPUAT, Pantnagar	2016
12.	Coriander	Ajmer Coriander 1 (ACr 1)	NRCSS, Ajmer	2016
13.	Coriander	Ajmer Coriander-2 (ACr-2)	NRCSS, Ajmer	2019
14.	Coriander	Ajmer Coriander-3 (ACr-3)	NRCSS, Ajmer	2019
15.	Coriander	JMU-07	SKUAST, Jammu	2017
16.	Coriander	Ajmer Green Coriander-1 (AGCr-1)	NRCSS, Ajmer	-
17.	Coriander	GDLC-1	SDAU, Jagudan	2016
18.	Coriander	Sudha	APHU, Lam, AP	2007
19.	Coriander	Arka Isha	IHR, Bengluru	2012
20.	Coriander	Gujrat Coriander-1	JAU, Junagadh	2022
21.	Coriander	Gujrat Coriander-1	JAU, Junagadh	2022
22.	Coriander	Kalmi	-	-
23.	Coriander	NO-56	-	-
24.	Coriander	T-5365	-	-
25.	Coriander	Gauri	-	-
26.	Coriander	Konkan Kasturi	BSKKV, Dapoli	2019
27.	Coriander	S-33	CIMAP, Lucknow	-
28.	Coriander	DH-5	CCSHAU, Hisar	1900
29.	Coriander	RCR-447	RARI, Durgapura	-
Fenugreek Varieties				
1.	Fenugreek	CO-2 (CF-390)	TNAU, Coimbatore	2001
2.	Fenugreek	RMT-305(UM-305)	RARI, Durgapura	2016
3.	Fenugreek	Azad Methi-1	CSAUAT, Kanpur	2006
4.	Fenugreek	Kasuri	IARI Karnal	1975
5.	Fenugreek	Pusa Early Bunching (PEB)	IARI, Karnal	-
6.	Fenugreek	RMT-1	RARI, Durgapura	1991
7.	Fenugreek	ML 150	PAU, Ludhiana	1996
8.	Fenugreek	Hisar Sonali (HM-57)	CCSHAU, Hisar	1996
9.	Fenugreek	Ajmar Fenugreek-1 (AFg-1)	NRCSS, Ajmer	-
10.	Fenugreek	Ajmar Fenugreek-4 (AFg-4)	NRCSS, Ajmer	2016
11.	Fenugreek	Ajmar Fenugreek-3 (AFg-3)	NRCSS, Ajmer	2016
12.	Fenugreek	Ajmar Fenugreek-5 (AFg-5)	NRCSS, Ajmer	2019
13.	Fenugreek	Methi Kasuri Supreme	SKUAST, Jammu	2017
14.	Fenugreek	RMT-350	RARI Durgapura	2016
15.	Fenugreek	Phule Kasturi	MPKV, Rahuri	2019
16.	Fenugreek	Methi-47	MPKV, Rahuri	-
17.	Fenugreek	Gujrat Methi-2	SDAU	2006
18.	Fenugreek	Lam Methi	APHU, Lam, AP	1992
19.	Fenugreek	Pant Ragini	GBPUAT, Pantnagar	-

PAU, Ludhiana; APHU, Lam (Andhra Pradesh); AU, Kota; IARI, Karnal (primarily for Kasuri methi); MPKV, Rahuri; and CSAUAT, Kanpur and GBPUAT, Pantnagar. The dominance of selected varieties and institutions in the seed chain, indicating a need for broader inclusion of diverse varieties and enhanced breeder seed planning across a wider range of seed spice crops.

Cumin Breeder Seed Status

Over the past decade (2015–16 to 2023–24), total indents for cumin breeder seed were 215.7 kg, with 137.05 kg allocation and 176.33 kg production. Breeder seed (BS) indent and production reveals a sharp increase in recent years, particularly from 2021–22 onwards. This trend reflects a renewed interest in cumin cultivation by farmer, driven by rising market demand and export potential, especially in Gujarat and Rajasthan (Meena *et al.*, 2021). Among the various cumin varieties, GC-4 emerged as the dominant variety, accounting for nearly all of the breeder seed indents and production in the last three years (0.75, 0.75 & 30.18), (64.75, 0.75 & 0.75), (135, 135 & 135) (kg) indent, allocation and production in 2021-22, 2022-23 and 2023-24 respectively. In contrast, other varieties received either negligible or no indent and had minimal or zero production, indicating a significant varietal skew in the seed chain in last three years. Prior to this period, cumin breeder seed indent was largely dormant, by RZ-223 variety, which has 11 kg indent in 2015–16 and 0.3 kg in 2016–17, but with limited or no corresponding production. While the recent surge in GC-4 adoption is promising, but dependence on a single variety raises concerns regarding genetic vulnerability. To mitigate risks of pest and disease outbreaks, it is imperative to diversify the varietal base by promoting and developing alternative high-yielding and stress-tolerant varieties.

Coriander Breeder Seed Status

In past one-decade total BS indent was received for different coriander varieties was 2571.5 kg against 1366.2 kg allocation and 7500.95 kg production. Over the years BS indent exhibited a significant increase, rising from about 96.5 kg in 2015–16 to 425.1 kg in 2022–23, reflecting growing demand from states and private agencies (Figure 2). The allocation closely followed the indents in most years, with occasional

shortfalls in 2022–23 and 2023–24. Notably, the production of BS exceeded both indent and allocation in four years (2017-18 to 2020-21), indicating strong institutional efforts in breeder seed multiplication by RARI Durgapura for varieties like RCR-436 & 435 and GBPUAT for variety Pant Haritma during 2018-19 where excess BS production was occurred as compared to indent. However, a downward trend in production was observed after 2019–20, despite consistent indents, likely due to climatic fluctuations or area reduction under seed production. Similar trends were reported in other crops where breeder seed shortfalls often stem from mismatch between seed production cycles and demand forecasts (Chand *et al.*, 2023, 2024 & 2025). These findings suggest that while institutional mechanisms for BS production are strong, sustainability may be affected by agro-ecological constraints.

Fenugreek Breeder Seed Status

In fenugreek total five times more BS was produced (10995.5 kg) as compared to indent (1988.15 kg), whereas 10 time was from BS allocation (1014.35 kg) from 2015-16 to 2023-24. This was due to higher BS production of varieties RMT-305 (4581 kg) and RMT-1 (4522 kg) by RARI Durgapura as compared to total indent of 356.75 kg & 134.5 kg respectively in last 10 years. The highest BS indent was consistently increasing since 2015-16 and highest was in 2021-22 where 438.6 kg indent was received for all varieties (Figure 3). In 2023-24 total BS indent was 287.25 kg against 45.75 kg allocation and 80 kg production, indicating the dependence of seed yield on seasonal conditions, institutional interest and available nucleus seed. This discrepancy highlights the need to strengthen linkages between BS production centers and state demand forecasts.

Dominance of Varieties in Seed Multiplication Chain

The cumulative breeder seed (BS) indent and production data over the last decade (2015–16 to 2023–24) highlight key performing varieties across cumin, coriander, and fenugreek based on total indent & production (Figure 4). In cumin GC-4 and RZ-223 were only two varieties in seed chain and Gujarat Cumin-4 (GC-4) recorded the highest indent (203 kg) and production (165.93 kg) as compared to RZ-223,

and 95% of total indent and production showed its agronomic superiority and market acceptance. In coriander, over the last decade variety, RCR-436 had the highest cumulative indent (572 kg), with production reaching 2060.5 kg, while RCR-435 had highest BS production (2982 kg) against 368.4 kg indent (Figure 4). The high breeder seed production exceeding indents in some coriander varieties suggests anticipatory seed multiplication practices by parent institutions or efforts to ensure buffer stock for future demand surges. The other dominant varieties are CS-6, SUDHA, and RCr-728 (UD-728) which showed moderate indents and corresponding production. In last years (2023-24) highest BS indent in coriander was received for Gujarat Dantewada (Leafy Coriander-1) (GDLC-1) (40 kg) followed by Pratap Raj Dhania-1 (RKD-18) (31 kg), CS-6 (30 kg), ACR-2 (21 kg) and Hisar Sugandh (21.75 kg). Varieties developed by ICAR-NRCSS, Ajmer showed upwards trend as BS indent was received for three varieties (ACr-1, ACR-2 and ACR-3) 11, 21 & 20 kg respectively. Pusa Early Bunching (PEB) and RMT-305 (UM-305) emerged as the top varieties in terms of indent (highest for PEB) and production (4581 kg for RMT-305). RMT-1 also showed substantial breeder seed production (4522 kg), though indent (134.5 kg) was moderate. Kasuri and RMT-350 had comparatively lower performance for production aspect (103.5 kg). during 2023-24, highest BS indent (135 kg) in fenugreek was received for Pusa Early Bunching (PEB) followed by RMT-350 (75 kg) and RMT-305, Azad Methi-1 & AFG-4 (all three 20.25kg each). During 2023-24 fenugreek BS production (45.75 kg) as compared to indent (287.25 kg) however, during 2022-23 total BS production (379 kg) was higher than indent (249.6). The data also highlight varietal dominance trends and potential areas for diversification to reduce dependency on a few cultivars.

Number of Varieties in Seed Chain (2015–16 to 2023–24)

An in-depth assessment of the seed chain dynamics for cumin, coriander, and fenugreek during the period from 2015–16 to 2023–24 reveals significant variations in the number of varieties entering the seed chain through breeder seed (BS) indents and subsequent production (Figure 5). The temporal analysis indicates a pronounced expansion in the diversity of varieties for

coriander and fenugreek, while cumin continues to exhibit limited varietal representation and production scale. This can be attributed to the crop's narrow genetic base and its vulnerability to multiple biotic and abiotic stresses. The limited scope for varietal improvement and restricted adaptability across regions have been previously documented (Ali *et al.*, 2006) emphasizing the need for targeted breeding strategies and stress-resilient genotypes. Additionally, cumin is highly susceptible to climate-induced diseases such as *Alternaria* blight and *Fusarium* wilt, further restricting its widespread seed production and varietal diversification (Meena *et al.*, 2021).

The number of coriander varieties indented showed a consistent and significant upward trend, particularly from 2020–21 onwards, highest 21 varieties in 2022–23, followed by a marginal decline to 18 in 2023–24. Similarly, fenugreek demonstrated substantial varietal growth, reaching a peak of 17 varieties in 2022–23 and slightly declining to 14 in 2023–24 (Figure 5). This trend reflects increasing emphasis on varietal diversification in these crops, likely driven by demand for traits such as early maturity, improved yield potential, pest and disease resistance, and adaptability to diverse agro-climatic regions. These findings emphasized the role of varietal improvement and diversification in enhancing productivity and farmer profitability in seed spices (Lal *et al.*, 2017).

For coriander, RCR-436 emerged as the most prominent variety with 572 kg of BS indent and 2060.5 kg of BS production. This was followed by RCR-435 and CS-6, both of which demonstrated substantial indents and production, highlighting their agronomic superiority and market acceptance. These varieties are known for traits such as uniform seed size, high essential oil content, and tolerance to leaf spot and powdery mildew, making them favorable choices for seed chain inclusion.

Sources of BS indent in seed spices

The source of breeder seed (BS) indents exhibited crop-specific variation over the past decade. In cumin, 100% of the BS indents originated from government agencies, indicating exclusive reliance on the public sector for seed multiplication. In contrast, coriander showed a more diversified pattern, with 76% of BS indents received from government sources and the

remaining 24% contributed by private seed companies affiliated with the National Seed Association of India (NSAI). A similar trend was observed in fenugreek, where 78% (1562 quintals) of the BS indents were submitted by government organizations, while 22% came from the private sector (Figure 6).

The major private seed companies actively participating in BS indents for coriander and fenugreek included Sardargrow Seeds Co. (P) Ltd, Malav Seeds Pvt. Ltd, Bombay Super Hybrid Seeds Ltd, Novogold Seeds Pvt. Ltd, USA Seeds, Anand Biotech, Matrabhumi Agrotech, KDM Seeds & Infrastructure Pvt. Ltd, Mahagujarat Seeds Pvt. Ltd, Upsurge Seeds of Agriculture Ltd, and Sahib Seeds Ltd. This engagement of private entities, particularly in coriander and fenugreek, highlights a growing interest from the commercial seed sector in seed spice crops, albeit still secondary to public sector dominance.

Prediction of foundation and certified seed production of cumin, coriander and fenugreek

The quality seed availability for cumin, coriander, and fenugreek was evaluated based on seed rate, seed multiplication ratio (SMR), cultivated area (2022–23), and seed production trends from 2023–24 to 2025–26. These inputs were used to estimate the potential coverage of certified seed and corresponding Seed Replacement Rate (SRR) for 2026–27.

For cumin, with a cultivated area of 902,010 hectares, and estimated seed requirement was 10,824.12 quintals. However, projected certified seed production for 2025–26 is only 5,703.75 quintals, covering 47,531.25 hectares, resulting in a low SRR of 5.27% (Table 2). This indicates a major gap in formal seed supply, although private sector contributions, which is currently unaccounted for cumin may improve actual coverage. In contrast, coriander showed a stronger seed system as total seed requirement is 63,865.2 quintals against 30,758 quintals of certified seed projected and the SRR reaches 48.16%, aligning well with national targets. This reflects effective institutional coordination, adoption of improved varieties, and greater farmer awareness. Similarly, in fenugreek also based of BS chain, SRR is 7.87% showed limited breeder seed supply, low commercial interest, and dependence on farm-saved seed (Table 2).

Conclusion

The analysis of breeder seed trends and seed chain dynamics across cumin, coriander, and fenugreek reveals significant crop-wise disparities in varieties in seed production, and system efficiency. Cumin remains constrained with only two varieties into the seed chain over the past ten years, whereas, coriander and fenugreek, which exhibited broader varietal representation with 29 and 19 varieties, respectively.

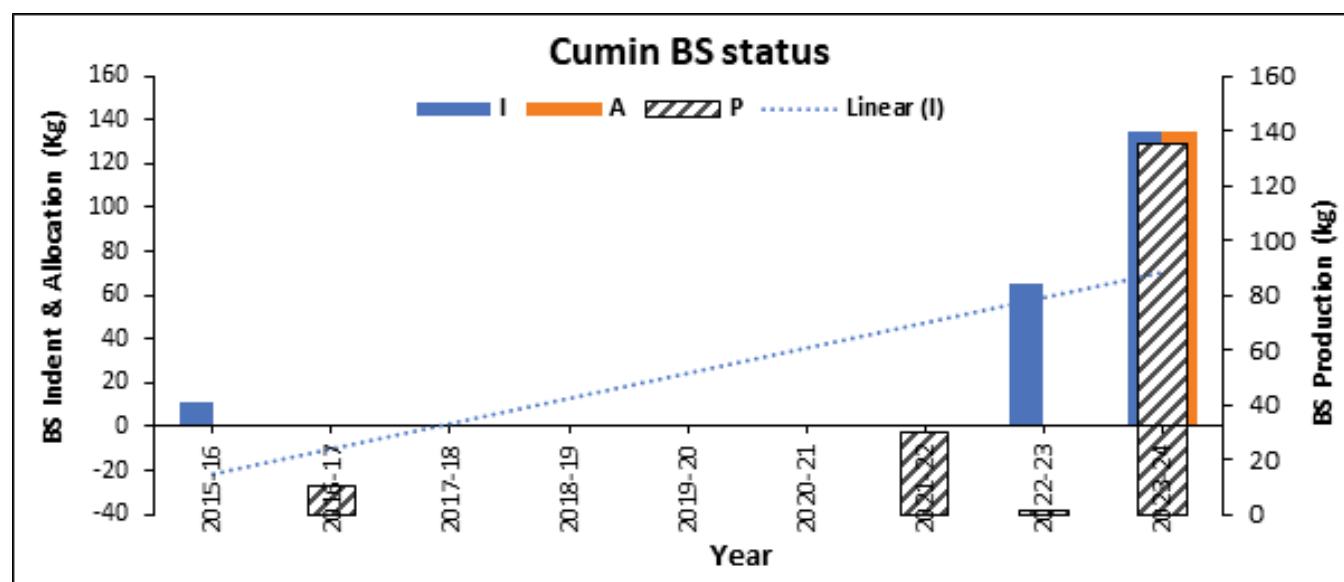


Figure 1: Cumin BS indent and production, over the last 10 years in seed chain (I: BS Indent; A: BS Allocation; P: BS Production)

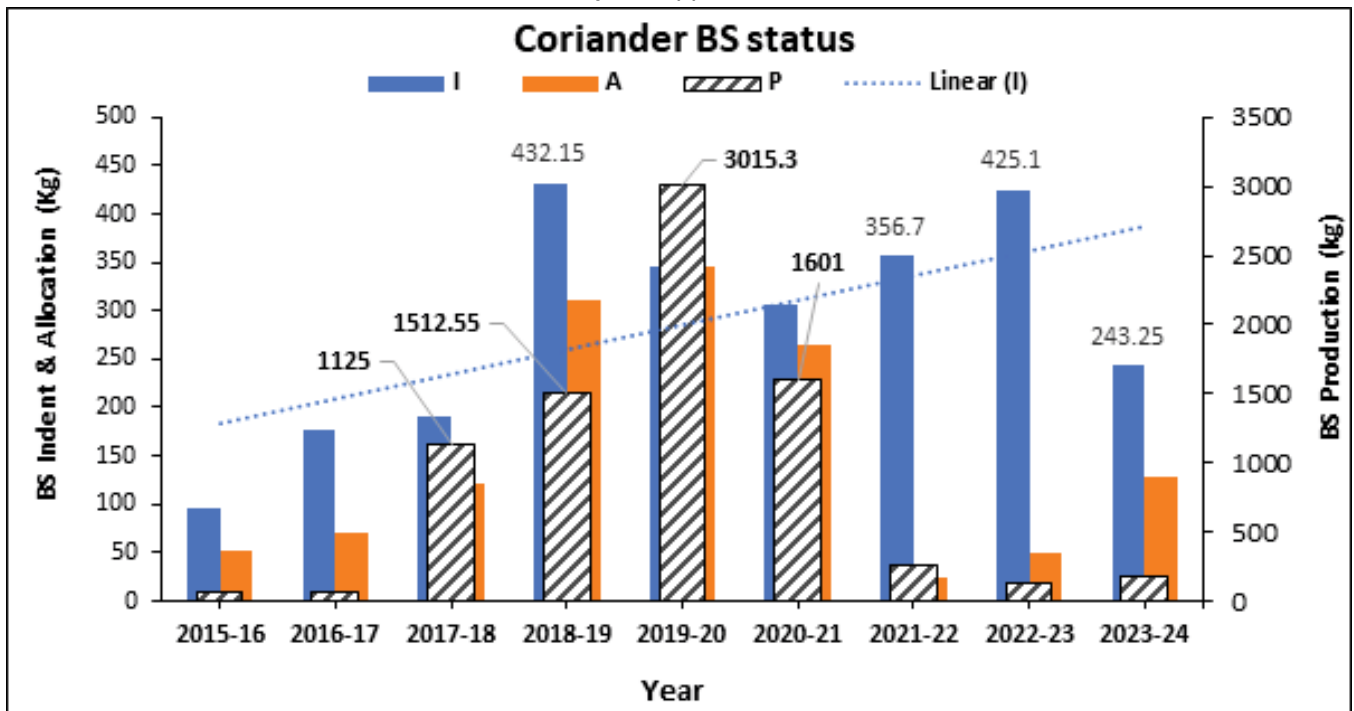


Figure 2: Coriander BS indent and production, over the last 10 years in seed chain (I: BS Indent; A: BS Allocation; P: BS Production)

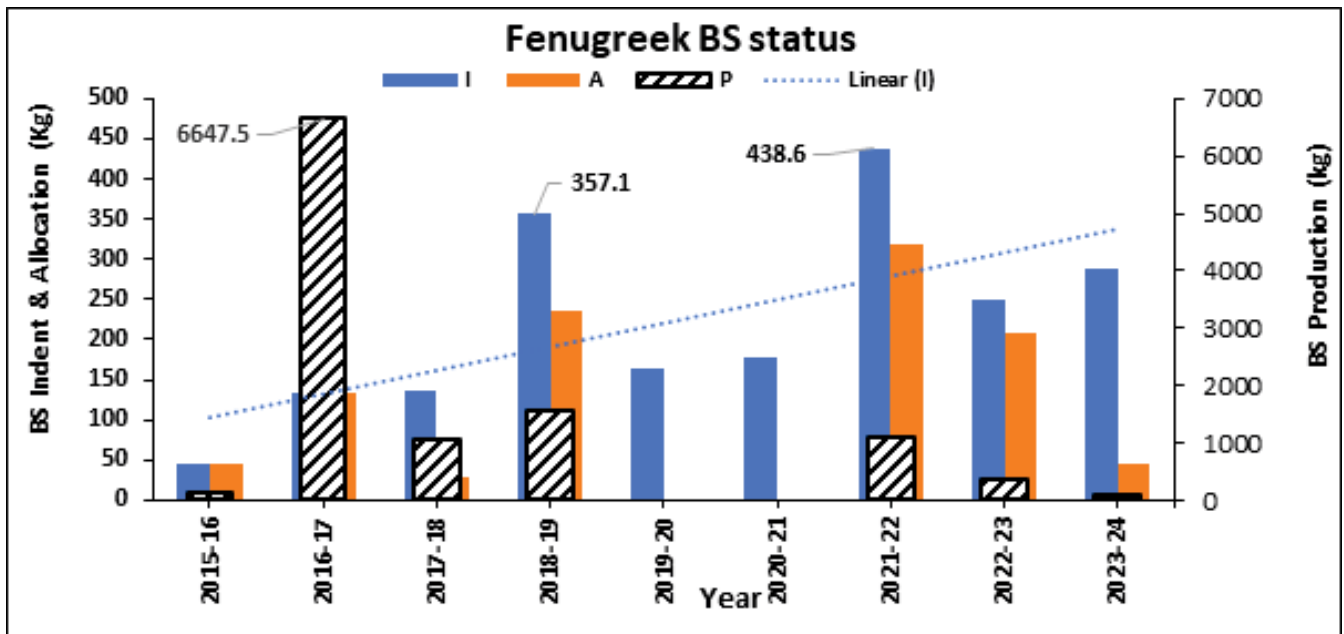


Figure 3: Fenugreek BS indent and production, over the last 10 years in seed chain (I: BS Indent; A: BS Allocation; P: BS Production)

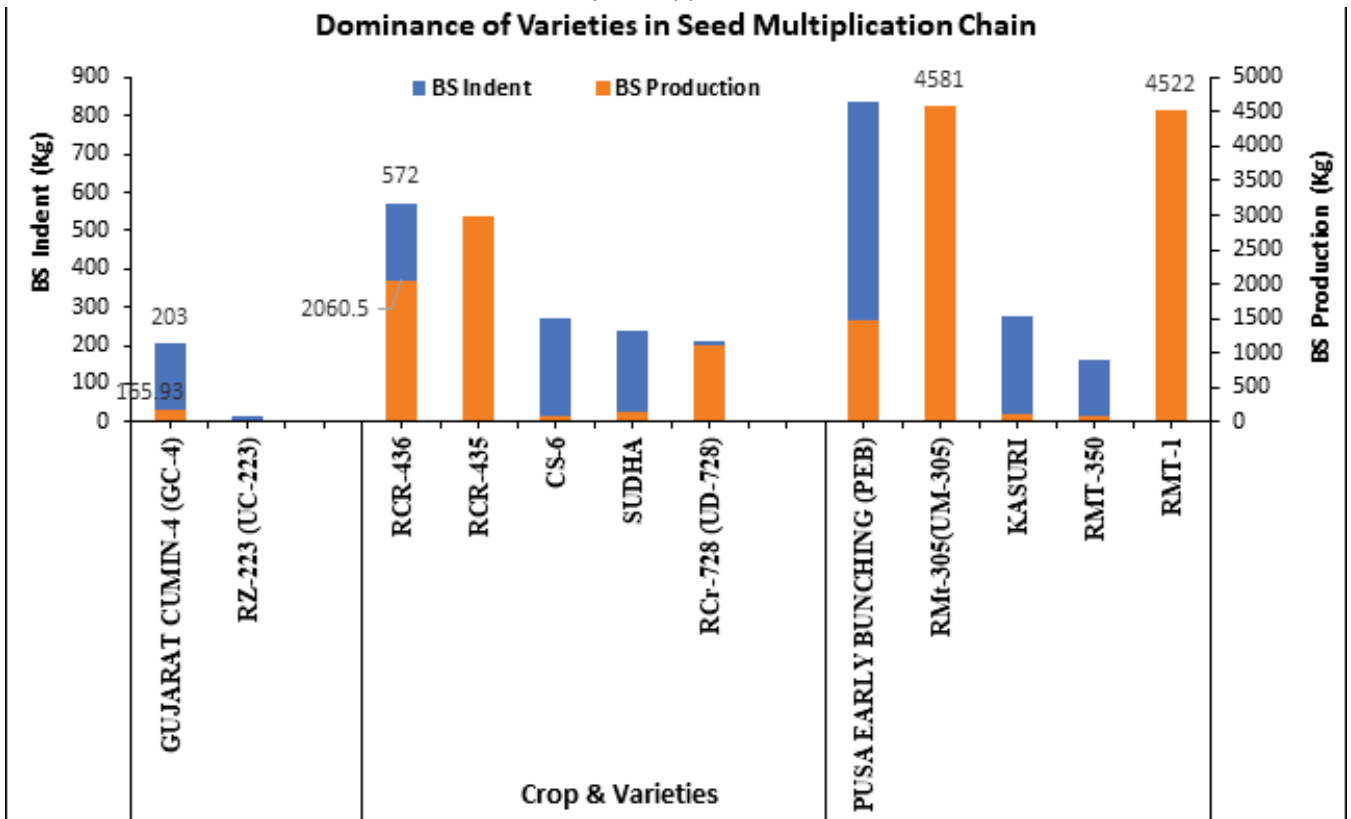


Figure 4: Cumulative BS indent & production (>10 years) for leading varieties (based on BS Indent) in seed spices (2015-16 to 2023-24)

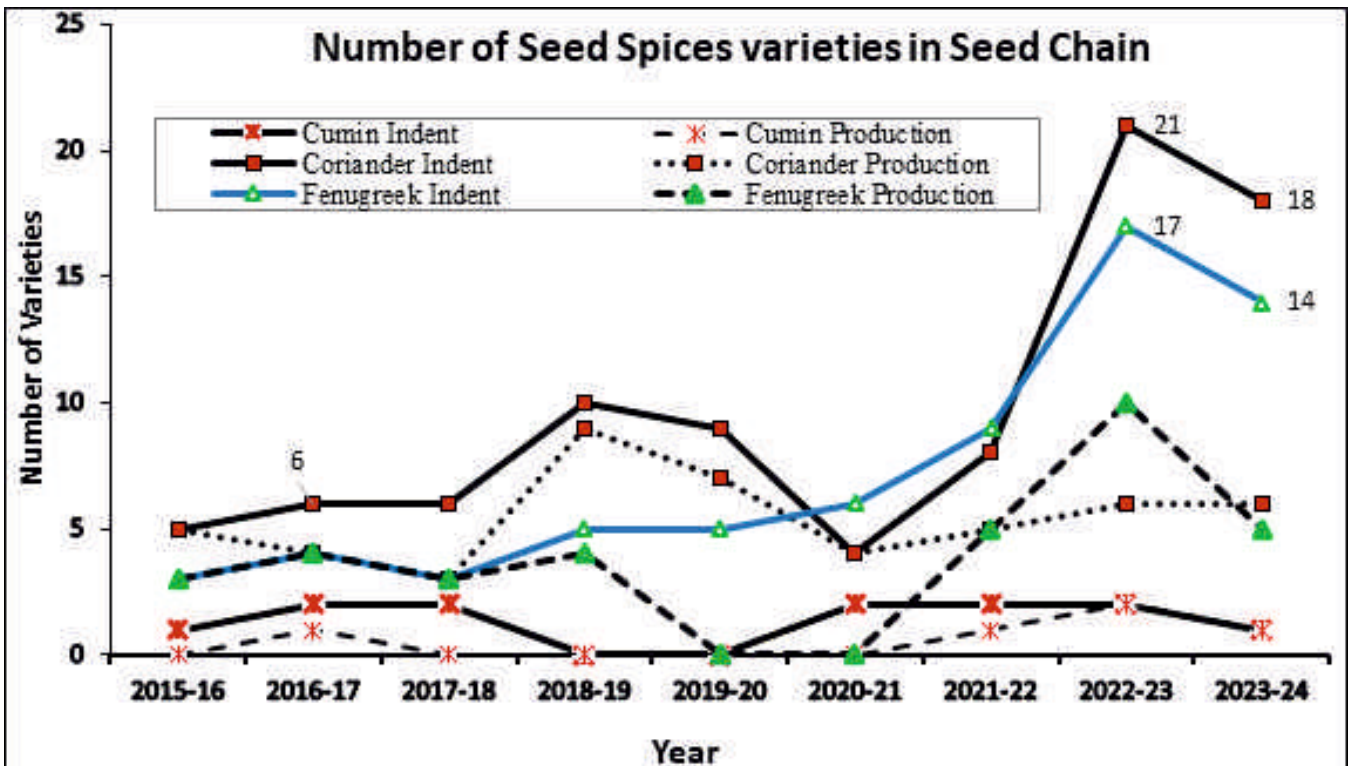


Figure 5: Variation in number of varieties for breeder seed indent to DAC & production by organizations

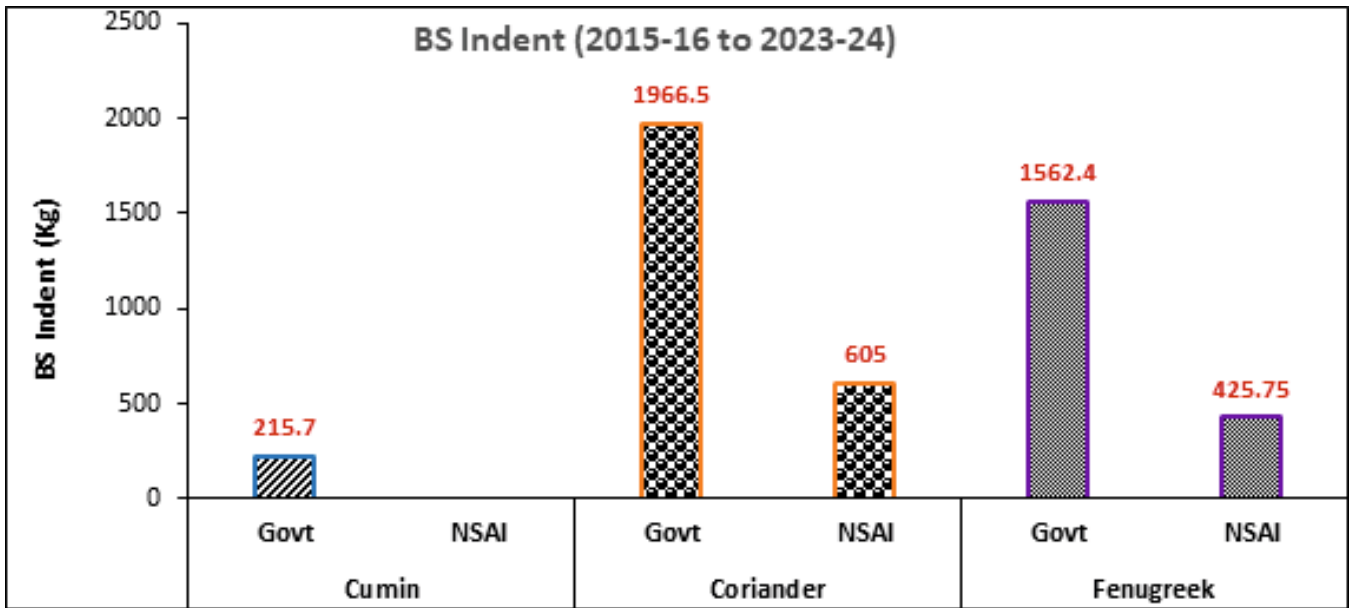


Figure 6: BS indent received from government and private organizations (2015-16 to 2023-24) (NSAI: National Seed Association of India)

Table 2: Prediction of foundation and certified seed for cumin, coriander and fenugreek from the available breeder seed in India.

S. N.	Crop	Seed rate (Kg/ha)	SMR	Approx . Area (ha) (2022-23)	Seed Requirement (q)			Seed Production (q)			Estimated area covered (ha) (2026-27)	% Area sown with CS
					BS	FS	CS	BS	FS	CS		
					2023-24	2024-25	2025-26	2023-24	2024-25	2025-26		
1.	Cumin	12	65	902010	25.6	1665.2	108241.2	1.35	87.75	5703.75	47531.25	5.27
2.	Coriander	10	130	638652	3.8	491.3	63865.2	1.82	236.6	30758	307580	48.16
3.	Fenugreek	25	60	146363	10.2	609.8	36590.8	0.8	48	2880	11520	7.87

Seed multiplication in all three crops remained concentrated around a few dominant varieties, limiting the reach of newly released cultivars. However, recent years (post-2020–21) have seen a positive trend in varietal diversification, particularly in coriander and fenugreek, suggesting an increasing focus on stress resilience and regional adaptability. GC-4 continues to dominate cumin breeder seed indents, accounting for over 95%, whereas, RCR-435, RCR-436 (in coriander) RMt-1 and RMt-305 (in fenugreek) were the dominant varieties. In coriander, breeder seed production frequently surpassed indents, particularly between 2017–18 and 2020–21, reflecting efficient buffer stock management. Conversely, fenugreek showed a supply demand mismatch, with BS production being five times

higher than the indent, primarily due to overproduction of RMt-1 and RMt-305. The cumin's breeder seed indents were entirely driven by government agencies, private sector involvement grew in coriander (24%) and fenugreek (22%), pointing toward gradual stakeholder diversification. Projected Seed Replacement Rates (SRR) for 2026–27 further underscore systemic imbalances in seed spices crops as coriander showed promising SRR (48.16%), whereas cumin (5.27%) and fenugreek (7.87%) lagged significantly. These findings underline the urgent need to strengthen varietal diversification, align breeder seed supply with actual demand, and foster public-private partnerships for a more resilient and inclusive seed system for India's seed spice sector.

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Conflict of interest

The authors declare that the research was conducted beyond any commercial or financial affairs that could be taken as a potential conflict of interest.

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