



Template/Pro forma for Submission

NMHS-Himalayan Institutional Project Grant

**NMHS-FINAL TECHNICAL REPORT (FTR)**

Demand-Driven Action Research and Demonstrations

NMHS Grant Ref. No.:	NMHS_MAH_SG_65	Date of Submission:	3	0	0	1	2	0	2	3
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**PROJECT TITLE (IN CAPITAL)**

**REVIVAL OF KALA ZEERA CULTIVATION THROUGH GERMPASM  
CONSERVATION AND LOCAL COMMUNITY BASED APPROACHES UNDER  
TRIBAL AREA CONDITIONS OF GUREZ VALLEY**

**Project Duration: *from* (10.10.2019) *to* (10.10.2022)**

**Submitted to:**

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## NMHS-Final Technical Report (FTR) *template*

### Demand-Driven Action Research Project

DSL: Date of Sanction Letter  
Completion

1	0	1	0	2	0	1	9
d	d	m	m	y	y	y	y

DPC: Date of Project

1	0	1	0	2	0	2	2
d	d	m	m	y	y	y	y

### Part A: Project Summary Report

#### 1. Project Description

i.	Project Grant Ref. No.:	<b>GBPNI/NMHS 2019-20/SG/305, Dated: 30-09-2019</b>					
ii.	Project Category:	Small Grant	/	Medium Grant	Large Grant		
iii.	Project Title:	<b>REVIVAL OF KALA ZEERA CULTIVATION THROUGH GERPLASM CONSERVATION AND LOCAL COMMUNITY BASED APPROACHES UNDER TRIBAL AREA CONDITIONS OF GUREZ VALLEY</b>					
iv.	Project Sites (IHR States/ UTs covered) (Location Maps attached):	Tehsil: Gurez; District: Bandipora UT: Jammu and Kashmir					
v.	Scale of Project Operation:	Local	/	Regional	Pan-Himalayan		
vi.	Total Budget:	<b>0.3948</b> (in Cr)					
vii.	Lead Agency:	Sher-e- Kashmir University of Agricultural Sciences and Technology of Kashmir					
	Lead PI/ Proponent:	<b>Dr. Mohd. Anwar Khan</b> , Professor, Division of GPB, Faculty of Agriculture, Wadura Campus, SKUAST-Kashmir					
	Co-PI/ Proponent:	<b>Dr. Reyazul Rouf Mir</b> , Associate Professor, Division of GPB, Faculty of Agriculture, Wadura Campus, SKUAST-Kashmir					
viii.	Implementing Partners:	Sub-Divisional Agriculture Officer, Department of Agriculture, Gurez Forest Range Officer, Department of Forestry, Gurez					
	Key Persons (Contact Details, Ph. No., E-mail):	<b>Tahir A. Mir</b> Forest Range Officer, Department of Forestry, Gurez Contact: 7889463368 <b>Mohammad Shamsuddin Baba</b> Progressive Kala zeera Farmer, Village-Nayle, Gurez Contact: 9469162245					

## 2. Project Outcomes

### 2.1. Abstract/ Summary (not more than 250-300 words)

**Background:** *Bunium persicum* (Bioss) is an important medicinal and aromatic herb. It is a low volume, high value ethano-medicinally important herbaceous species widely used for culinary, flowering, perfumery and carminative purposes (Pourmortazavi *et al.* 2005). It grows wild in the dry temperate regions of Central Asia, including India, Iran, Egypt, Pakistan, Afghanistan and Kazakhstan (Panwar, 1992). In India, *B. persicum* grows wild in alpine and sub-alpine habitats of north-west Himalayan states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Gurez is one of the most important kala zeera growing area in the Union Territory (UT) of Jammu and Kashmir, which is thought to harbour various sub-populations within its forest pockets possessing significant variability for this crop (Khan *et al.*, 2022). This variability has been observed in the form of land races that exist in higher reaches of Gurez valley. In the recent past continuous unscientific and ruthless exploitation of this crop by locals of these areas for immediate financial gains has led to low productivity and genetic erosion of this crop. The drastic reduction in area in this way under this crop has further aggravated the situation. If this situation is not taken care of, the crop area under Kala zeera may soon become drastically reduced which may, ultimately, lead to heavy economic losses or extinction of this spice. By far, the forest areas of Gurez contribute maximum to the zeera production of the UT and as such judicious domestication of this crop on scientific lines in this area for commercial cultivation is expected to contribute significantly. Further the efficient utilization of the genetic resources available in this crop species could be initiated through breeding by means of establishment of a kala zeera germplasm bank. The domestication of this crop on scientific lines and establishment of diverse germplasm bank in kala zeera have potential to contribute in enhancement of production and productivity and initiation of a full-fledged plant breeding programme for genetic improvement of Kala zeera in this area. Such issues could be well addressed through implementing partners and representatives of tribal communities of Gurez under the technical support and guidance of SKUAST-Kashmir.

#### **Objectives/ Aim:**

- To survey for collection of existing of genetic variability, its characterization and evaluation for establishment of germplasm bank.
- To enhance production of quality planting materials (root tubers) for domestication on marginal foothills and in farmer's field for boosting its production and productivity.
- To conduct trainings/ awareness programmes of tribal farmers on "Scientific cultivation of Zeera cultivation and its post-harvest handling and value addition"
- DNA fingerprinting of local Zeera germplasm

**Methodology/Approach:** The Kala zeera growing villages of Gurez valley viz., Nayle, Chorwan, Chuntiwari, Khandyal, Markoot, Dawar, Wanpora & Koragbal; other important Kala zeera growing areas of Kashmir valley, Himachal and Uttarakhand were surveyed for identification of genetic variability and tagging of plants.

The initial level of character variation was documented along with the spot number with area as reference data. With the help of implementing agencies and local farmers' kala zeera tubers/ seed samples were collected from these areas of Gurez entry-wise during years 2019-20 and 2020-21 for their establishment at MAR&ES, SKUAST-K Gurez. Out of more than 4000 samples collected, only 930 samples could germinate and establish at MAR&ES, SKUAST-K, Gurez. Out of 930 established accessions of Kala zeera, a core set of 252 diverse accessions could be identified on the basis of morphological characterization based on ten yield and yield related traits. In total around 930 accessions were established at SKUAST-Kashmir, Gurez (longitude – 34°39 19.822°N, latitude – 74°41'23.087°E) evaluated in augmented block design (ABD) with spacing of 30 × 20 cm. Out of these, a core set of 252 diverse Kala zeera accessions was established on the basis of their morphological characterization for yield and yield attributing traits. The entire set of Kala zeera accessions were evaluated for different agro-morphological and quality traits at MAR&ES Gurez and Molecular biology laboratory at Faculty of Agriculture, SKUAST-K, Wadura during the year 2020-21. The selection of genetically diverse/ elite stocks (252 accessions) was done based on morphological data and quality parameters, these selections constituted a Kala zeera Germplasm Bank. The analysis of the data recorded from seed characterization using Image-J software revealed significant diversity for seed length, breadth, size (feret) and area (perimeter) and out of this data, accessions viz., KZG104, KZG120, KZG123, KZG127, KZG126 and KZG134 with superior seed traits were identified. The biochemical studies involved estimation of total Protein from 252 diverse accessions/ landraces using methanol extraction method as described by Das *et al* (2014). The principal component analysis demonstrated diverse protein content across 252 accessions. The study identified five accessions viz., KZG4 (4.640mg/ml), KZG114 (4.535 mg/ml), KZG3 (4.4325 mg/ml), KZG9 (4.3325 mg/ml), KZG30 (4.3325 mg/ml) with highest protein content. For molecular characterization of 252 kala zeera accessions, the total genomic DNA was isolated from leaf samples collected from each accessions using CTAB method as proposed by Saghai-Marroof *et al.* (1984). The quality and quantity of DNA was tested using standard procedures. From the recently published literature (Bansal *et al* 2022) on development of genomic SSRs in Kala zeera, around 25 SSR primer sequences have been selected on the basis of PIC value, for establishment of diversity across kala zeera accessions. In total fifty-five primers were ordered for synthesis from Sigma-Aldrich, Bangalore. The primer sequences were diluted in Tris-EDTA buffer solution for making primer stocks and later further diluted to appropriate working concentrations using double distilled water. Around 600 tribal farmers were given on field trainings at MAR&ES, Gurez and through awareness programmes at their respective villages. These programmes gave emphasis on different agronomic practices and scientific cultivation, post-harvest handling and value addition of the crop. Twenty five frontline demonstrations of improved kala zeera selections were distributed to different villages of Gurez valley.

**Results/ Outcomes:** Diversity of around 252 Kala zeera accessions/ landraces has been established through morphological, seed and quality characterization. The collections were established at Mountain Agriculture Research & Extension Station, SKUAST-K, Dawar, Gurez as “Kala zeera Germplasm Bank”.

The results of molecular characterization coincided and confirmed the findings of morphological studies, as molecular characterization could group most of the high yielding accessions separately and could also clearly isolate a morphological distinct accession. One hundred two (102) elite landraces/ accessions have been registered with NBPGR, New Delhi. The analysis of the data recorded from seed characterization using Image-J software revealed significant diversity for seed length, breadth, size (feret) and area (perimeter) and out of this data, accessions viz., KZG104, KZG120, KZG123, KZG127, KZG126 and KZG134 with superior seed traits were identified. The biochemical studies involved estimation of total Protein from 252 diverse accessions/ landraces using methanol extraction method as described by Das *et al* (2014). The principal component analysis demonstrated diverse protein content across 252 accessions. The study identified five accessions viz., KZG4 (4.640mg/ml), KZG114 (4.535 mg/ml), KZG3 (4.4325 mg/ml), KZG9 (4.3325 mg/ml), KZG30 (4.3325 mg/ml) with highest protein content. In total, one report, three booklets, two leaflets, one policy document and one success story are already published, two research paper have also been published in International journals of repute.

**Conclusions:** Under collection and conservation of landraces in total around >4000 indigenous, entries have been collected from different kala zeera growing areas of Gurez. Morphological Characterization based on ten traits could identify a set of 252 diverse accessions which led to establishment of a Kala Zeera Germplasm Bank at MAR&ES Gurez. One hundred two (102) diverse accessions were recognized by National Bureau of Plant Genetic Resources, New Delhi and accordingly the accessions were registered with allotment of IC numbers. In molecular characterization of 252 Kala zeera accessions using 25 SSR primers revealed confirms the existence of huge diversity among accessions under study, which could be well harvested through initiation of trait specific plant breeding programmes. These accessions completely appeared in the different groups, thus depicting the level of genetic dissimilarity and the variation that can specifically be used for the future breeding programs for selecting the most diverse accessions for different hybridization programs and further genetic or genomic studies. The accessions KZG112, KZG192, KZG272, KZG208, KZG215 were identified as most promising landraces (Appendix 5) based on their overall performance. Germplasm exchange programme with Himachal Pradesh and Uttarakhand was taken up with KVK Kinnaur and Almora, The germplasm shared with these centres could not get established in these locations. However, we were successful in establishing collections from Lahual Spiti, Shaung, Bharmour villages of Himachal Pradesh at MAR&ES Gurez, but most of which couldnot germinate in second year of establishment.

In total 600 tribal farmers have been trained for domestication/ scientific cultivation of Kala zeera crop and 25 frontline demonstration trials were given to selected farmers to initiate domestication of this crop. Kala zeera accessions with high nutritional/ medicinal values have been identified. In total, one report, three booklets, two leaflets, one policy document and one success story are already published, two research paper have also been published in International journals of repute.

***Recommendations/ Way Forward with Exit Strategy:*** The collection and conservation campaign for other IHR states (Himachal Pradesh and Uttarakhand) could separately be taken up as in our study most of the accessions collected from outside Jammu and Kashmir couldnot survive after one year of establishment. For which specific climatic requirement or prolonged chilling or over wintering could be one of the reasons. As such a separate germplasm bank could be established for these areas outside Jammu and Kashmir. The elite and diverse accessions identified from the study were conserved for their future use. One hundred two (102) accessions were recognized by national gerrmplasm repository agency NBPGR, New Delhi and were assigned accession numbers. Now breeder in need for improvement of any trait of economic importance in Kala zeera can directly get its reference accession from NBPGR, New Delhi.

## 2.2. Objective-wise Major Achievements

S. No.	Objectives	Major achievements ( <i>in bullets points</i> )
01	To survey for collection of existing of genetic variability, its characterization and evaluation for establishment of germplasm bank.	<ul style="list-style-type: none"> <li>• Under collection and conservation of landraces in total around &gt;4000 indigenous, entries have been collected from different kala zeera growing areas of Gurez.</li> <li>• Morphological Characterization based on ten traits could identify a set of 252 diverse accessions which led to establishment of a Kala Zeera Germplasm Bank at MAR&amp;ES Gurez. .</li> <li>• Kala zeera accessions with high nutritional/ medicinal values have been identified.</li> <li>• Germplasm exchange programme with Himachal Pradesh and Uttarakhand was taken up with KVK Kinnaur and Almora, The germplasm shared with these centres could not get established in these locations. However, we were successful in establishing collections from Lahual Spiti, Shaung, Bharmour villages of Himachal Pradesh at MAR&amp;ES Gurez, However most of such tubers did not germinate in subsequent year.</li> </ul>
02	To enhance production of quality planting materials (root tubers) for domestication on marginal foothills and in farmer's field for boosting its production and productivity.	<ul style="list-style-type: none"> <li>• One hundred two (102) diverse accessions were submitted to NBPGR, New Delhi and accordingly the germplasm was registered with allotment of IC numbers.</li> <li>• Twenty five (25) frontline demonstration trials were given to tribal farmers from different villages of Gurez to promote domestication of the crop.</li> <li>• Five high yielding Kala zeera landraces (Appendix 5) have been identified which have potential to out yield our present variety Shalimar Kala zeera-1.</li> </ul>

03	To conduct trainings/ awareness programmes of tribal farmers on “Scientific cultivation of Zeera cultivation and its post-harvest handling and value addition”	<ul style="list-style-type: none"> <li>• In total around 600 tribal farmers have been trained for domestication/ scientific cultivation of Kala zeera crop</li> <li>• In total, one report, two booklets, one package and practice, two leaflets, one policy document and one success story are already published. Two research papers have also been published in journals of repute.</li> </ul>
04	DNA fingerprinting of local Zeera germplasm	<ul style="list-style-type: none"> <li>• In molecular characterization of 252 Kala zeera accessions using 25 SSR primers significant diversity was revealed through the principal coordinate analysis, which separated the 252 accessions into different groups, which was consistent with assignments generated by UNJ dendrogram.</li> <li>• This confirms the existence of diversity among accessions under study.</li> <li>• The molecular DARwin cluster analysis also showed that zeera accessions collected from different regions of western Himalayas had huge genetic diversity. These accessions completely appeared in the different groups, thus depicting the level of genetic dissimilarity and the variation that can be used for the future breeding programs for selecting the most diverse accessions for different hybridization programs and further genetic or genomic studies.</li> </ul>

Note: Further details may be summarized in DPR Part-B, Section-5. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

### 2.3. Outputs in terms of Quantifiable Deliverables\*

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations, if any, & Remarks thereof:
1	Collection and conservation of landraces and development of Kala zeera germplasm bank (>3000 Accessions)	Number of accessions collected/ conserved	Collected and conserved= 4000 and 953 Diverse Germplasm Bank= 252	Nil
2	Registration of	Number of land	102 landraces have been	Due to less



	collected and characterized zeera landraces with NBPGR, New Delhi.	racces registered	registered with NBPGR, New Delhi	seed yield samples of remaining accessions/ landraces couldnot be send for registration
3	Database on nutritional and medicinal profile of collected accession to identify elite accession	Data base developed (No.)	Total protein content data base= 01 Seed quality characterization= 01 Data base of Morphological and Molecular characterization of 252 accessions = 02	Nil
4	Development of package of practices for Kala zeera cultivation for local farmers (100 farmers)	Number of trainings or awareness programmes organised	Total number of training programmes= 06 Total number of awareness camps= 10 Total number of beneficiaries= 600	Nil
5	Improvement in economy of local poor farmers through training camp (100 farmers)	Number of beneficiaries of village SC/ST/ local	Total number of beneficiaries (Local ST farmers) = 600	Nil
6	Develop the strategic plan for domesticating the Kala zeera crop on scientific lines	-	A package and practice for cultivation of Kala zeera on scientific lines was developed, farmers were trained and twenty five (25) frontline demonstrations of improved genotypes were given to farmers for cultivation to initiate domestication of this crop in villages of Gurez. The selected better performing genotypes of Kala zeera are being multiplied and tested further for their release as varieties.	Nil
7	Develop 05 knowledge products: 01 Policy manual document, 01 package, 01 success story and 2 publications in well reputed journal	Number of reports/research articles/ policy documents prepared and published	Reports= 01 Research articles= 02 Policy documents= 01 Booklets (English) = 02 Booklets (Urdu) = 02 Package= 01	Nil

\*As stated in the Sanction Letter issued by the NMHS-PMU.

#### 2.4. Strategic Steps with respect to Outcomes (in bullets)

S. No.	Particulars	Number/ Brief Details	Remarks/ Attachment
1.	New Methodology/ Technology developed, <i>if any</i> :	Package developed for scientific cultivation of Kala zeera in Gurez	(Attached)
2.	New Ground Models/ Process/ Strategy developed, <i>if any</i> :	Domestication of crop on Scientific lines in Gurez	Development of complete package of practice for cultivation
3.	New Species identified, <i>if any</i> :	Nil	Nil
4.	New Database established, <i>if any</i> :	Two	Protein content; Seed characters Morphological traits
5.	New Patent, <i>if any</i> :		
	I. Filed (Indian/ International)	NIL	-
	II. Technology Transfer, <i>if any</i> :	NIL	-
6.	Others, <i>if any</i>	One accession with some unique traits was identified and morphologically and molecularly characterized	DNA sample of unique accession is intended to be sequenced in comparison to control genotype to draw some valid conclusion

Note: Further details may be summarized in DPR Part-B, Section-5. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

#### 3. New Data Generated over the Baseline Data

S. No.	New Data Details	Status of Existing Baseline	Addition and Utilisation New data
01	<b>Morphological Characterization</b>	No information on landraces was available	Kala zeera landraces/ accessions from Gurez and other areas were collected, established at MAR&ES Gurez. Morphological characterization of 252 accessions lead to establishment of diverse germplasm bank of Kala zeera in Gurez.
02	<b>Seed Characterization</b>	No information on seed characters of landraces was available	Seed samples of around 252 diverse accessions was analysed using Image J and accessions with promising seed characters were selected. Such accessions could be exploited under a Kala zeera breeding programme.

<b>03</b>	<b>Protein content</b>	No information on total protein content of landraces was available	Seed samples of around 252 diverse accessions was analysed using standard procedures for estimation of total protein and accessions with promising protein content were identified that could be exploited through breeding programmes.
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*Note:* Further details may be summarized in DPR Part-B. Database files in the requisite formats (Excel) may be enclosed as annexure/ appendix separately to the soft copy of FTR.

#### 4. Demonstrative Skill Development and Capacity Building/ Manpower Trained

S. No.	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	ST	Women	Total
1.	Workshops	Nil	Nil	-	-	-	-
2.	On-Field Trainings	600 tribal farmers (Men= 520; Women= 80)	Awareness cum Training Programmes on conservation of Kala zeera in Gurez; Scientific cultivation of Kala zeera	Nil	600	80	600
3.	Skill Development	Nil	Nil	Nil	-	-	-
4.	Academic Supports	-	-	-	-	-	--
	Others (if any)	Kala Zeera Day at Gurez	Distribution of twenty five (25) frontline demonstration trials of improved Kala zeera accessions to tribal farmers from different villages of Gurez	-	60	5	60

*Note:* Further details may be summarized in DPR Part-B. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

### 5. Linkages with Regional & National Priorities (SDGs, INDC, etc.)/ Collaborations

S. No.	Linkages /collaborations	Detail of activities (No. of Events Held)*	No. of Beneficiaries
1.	Sustainable Development Goals (SDGs)/ Climate Change/INDC targets addressed	Under the banner of Azadi Ka Amrit Mahotsav (celebration of 75th anniversary of Indian Independence) Kala Zeera Day was observed on 2nd of October, 2021 at Mountain Agriculture Research and Extension Station SKUAST-K Gurez under NMHS funded research project "Revival of Kala Zeera Cultivation Through Germplasm Conservation and Local Community Based Approaches under Tribal Area Conditions of Kashmir Valley". The occasion witnessed the presence of tribal farmers from villages of Nayle, Iz marg, Chuntiwari, Jalindoor a, Khopri, Achoora, Chorwan etc. In an attempt to conserve Kala zeera and promote its scientific cultivation, twenty five Front Line Demonstrations (FLDs) were distributed to the participating farmers identified from different villages by local panchayats. Professor A. H. Hakeem, Dean Faculty of Agriculture, was chief guest of the occasion, who stressed upon importance of conservation of Kala zeera for economic upliftment of farmers of Gurez valley. Dr. M. Anwar Khan, Principal Investigator of the project gave brief account of activities under the NMHS funded project on kala zeera and also gave emphasis on the area expansion, value addition and marketing of Kala zeera. Dr. Bilal A. Bhat, Scientist Incharge MAR&ES, Gurez spoke about the activities of the station. Community leaders of the area applauded the role of NMHS and SKUAST-Kashmir in sensitizing farmers regarding conservation and protection of Kala zeera, the niche crop of the area and these initiatives are bringing fruits through creation of Kala zeera conservation groups in the villages.	60
2.	Any other:	Village-wise campaigns on "Contribute towards conservation of zeera by stopping its immature harvest from hills" = 12 (twelve)	500

*Note:* Further details may be summarized in DPR Part-B, Section-6. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

## 6. Project Stakeholders/ Beneficiaries and Impacts

S. No.	Stakeholders	Support Activities	Impacts in terms of income generated/green skills built
1.	Line Agencies/ Gram Panchayats:	Panchayat Bagtore Panchayat Kanzalwan Panchayat Shahpora Bala Panchayat Shahpora Payeen/ Achhora Panchayat Khopri, Panchayat Budlinder-A	From each panchayat ten farmers were trained for conservation, domestication through scientific cultivation
2.	Govt Departments (Agriculture/ Forest/ Water):	Department of Agriculture, Gurez Department of Forestry, Gurez	Efforts were made by these implementing agencies towards selection of innovative farmers and motivate them to adopt domestication of zeera through scientific cultivation.
3.	Villagers/ Farmers:	25 frontline demonstration trials favouring 25 innovative farmers to start domestication	The performance of selected zeera genotypes under domestication was enormous and was also praised by Honourable Vice Chancellor SKUAST-K on his visit during June, 2022.
4.	SC Community:	Nil	-
5.	ST Community:	All	-
6.	Women Group:	Razdan Women Club, Habba khatoon Women club	Inspired by our domestication process, a local women Mtr. Khateeja Begum had herself fenced an area on hill to give it a protection against stray animals. She was felicitated for it in a local event.
	Others, if any:	-	-

*Note:* Further details may be summarized in DPR Part-B, Section-6. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

## 7. Financial Summary (Cumulative)

Please attach the consolidated and audited Utilization Certificate (UC) and Year-wise Statement of Expenditure (SE) separately, *ref. Annexure I.*

## 8. Major Equipment/ Peripherals Procured under the Project\*\* (if any)

S. No.	Name of Equipment	Quantity	Cost (INR)	Utilisation of the Equipment after project
1.	Digital Camera	01	50,000	Entered in Stock Register of Division so that it is available for further use in Faculty/ University
2.	Gel Electrophoresis Unit	01	3, 50,000	Entered in Stock Register of Division so that it is available for further use in Faculty/ University

\*\*Details should be provided in details (*ref. Annexure III &IV.*)

## 9. Quantification of Overall Project Progress

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
1.	IHR States/ UTs covered:	03	Jammu and Kashmir, Himachal Pradesh & Uttarakhand
2.	Project Sites/ Field Stations Developed:	01	Kala zeera Germplasm Bank at MAR&ES Gurez
3.	Scientific Manpower Developed (PhD/M.Sc./JRF/SRF/ RA):	02	Two Junior Research Fellows
4.	Livelihood Options promoted	600	Farmers were trained for scientific cultivation of Kala zeera
5.	Technical/ Training Manuals prepared	02	Reports= 01 Scientific Package= 01
6.	Processing Units established, if any	NIL	-
7.	No. of Species Collected, if any	>4000	Survey and collection of Kala zeera accessions was limited to three states/ UT Jammu and Kashmir, Himachal Pradesh & Uttarakhand
8.	No. of New Species identified, if any	One	For confirmation Sample has been submitted for DNA sequencing

9.	New Database generated (Types):	03	<ul style="list-style-type: none"> <li>• Morphological Characterization</li> <li>• Seed Characterization</li> <li>• Protein Characterization (Appendix-8)</li> </ul>
	Others (if any)	-	-

*Note:* Further details may be summarized in DPR Part-B. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

#### 11. Knowledge Products and Publications (refer Appendix-3):

S. No.	Publication/ Knowledge Products	Number		Total Impact Factor	Remarks/ Enclosures (Attached)
		National	International		
1.	Journal – Research Articles/ Special Issue:	-	02	3.698	Two (Appendix-3)
2.	Book – Chapter(s)/ Monograph/ Contributed:	05	-	-	Research articles= 02 Booklets (English) = 02 Booklets (Urdu) = 01 (Appendix-3)
3.	Technical Reports:	01	-	-	One
4.	Training Manual (Skill Development/ Capacity Building):	01	-	-	One package has been developed for scientific cultivation of Kala zeera in Gurez (Appendix-3)
5.	Papers presented in Conferences/Seminars:	06	-	-	Copies attached
6.	Policy Drafts/Papers:	01	-	-	Copy attached
7.	Others, if any:	-	-	-	-

*Note:* Please append the list of KPs/ publications (with impact factor, DOI, and further details) with due Acknowledgement to NMHS. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

## 12. Recommendation on Utility of Project Findings, Replicability and Exit Strategy

Particulars	Recommendations
<p><b>Utility of the Project Findings:</b></p>	<ul style="list-style-type: none"> <li>✓ The collections were established at Mountain Agriculture Research &amp; Extension Station, SKUAST-K, Dawar, Gurez. The 930 kala zeera collections were evaluated and 252 elite and diverse core set was selected . This diverse core set of 252 entries led to establishment of Kala zeera Germplasm Bank at MAR&amp;ES, SKUAST-K.</li> <li>✓ The DNA fingerprinting of 252 Kala zeera accessions proved their diversity at molecular level and such their importance and use in future plant breeding programmes could be justified.</li> <li>✓ The elite and diverse accessions identified from the study were conserved for their future use. One hundred two (102) accessions were recognized by national germplasm repository agency NBPGR, New Delhi and were assigned accession numbers. Now breeder in need for improvement of any trait of economic importance can directly get it from NBPGR, New Delhi.</li> <li>✓ Promising accessions identified on the basis of seed characterization and protein content could efficiently be exploited through breeding programmes.</li> </ul>
<p><b>Replicability of Project/ Way Forward:</b></p>	<p>The collection and conservation campaign for other IHR states (Himachal Pradesh and Uttarakhand) could separately be taken up as in our study most of the accessions collected from outside Jammu and Kashmir couldnot survive after one year of establishment. For which specific climatic requirement or prolonged chilling or over wintering could be one of the reasons. As such a separate germplasm bank could be established for these areas outside Jammu and Kashmir.</p> <p>The elite and diverse accessions identified from the study were conserved for their future use. One hundred two (102) accessions were recognized/registered (Appendix-6) by national germplasm repository agency NBPGR, New Delhi and were assigned accession numbers. Now breeder in need for improvement of any trait of economic importance in Kala zeera can directly get its reference accession from NBPGR, New Delhi.</p>



**Exit Strategy:**

Kala zeera needs to be cultivated on scientific lines by the local tribes. This will not only help in conservation of local biodiversity, but will also help in increasing production and productivity of this crop. Evaluation/ screening of genotypes for identification of high yielding and elite accessions is important in sustainability of this crop. High yield would mean high economic returns to the farmer and hence more demand for cultivation of this crop. Cumin seeds have an aromatic odour and bitter taste. It can be used as a condiment and as an ingredient in curry powders, seasonings of breads, cakes and cheese. The value added products like zeera powder, roasted powder, oil, drinks and food product ingredients such as zeera ladoo, zeera goli, zeera roasted powder, zeera sweet, aaloo zeera, zeera poli, zeera chicken, zeera puffs, roasted zeera bread sticks, zeera bhakhri, zeera cookie, zeera cheese pakooda, zeera biscuits and zeera cheese can be prepared from it. This is expected to give employment to tribal youth besides would led to improvement of market for these value added products. These rural youth can establish e-marketing channels for promoting their products outside state and country. To achieve success, each promotion activity should be a group activity. This is possible only when farmers cooperatives are in place. It becomes easy to promote products of choice/ demand, establish contacts with Government agencies and address the issues and difficulties of common farmers when such cooperatives are well established in an area.

**(PROJECT PROPONENT/ COORDINATOR**

**(Signed and Stamped)**

**(HEAD OF THE INSTITUTION/ DEAN)**

**(Signed and Stamped)**

**Place: .....**

**Date: ...../...../.....**

## PART B: DETAILED PROJECT REPORT

### 1. EXECUTIVE SUMMARY

Kala zeera (*Bunium persicum* Boiss.) grows in its natural habitat (hills and terrains) across north-western Himalayan UT/states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Among several regions/hot-spots in Kashmir, Gurez, Machil, Kargil, Drass, Vasturvan, Char-e-Sharief and Paddar are considered its natural habitats. The latest area and production figures are not well documented for this crop however, as per the figures of state forest department of J&K of the year 1996-97, average productivity of Kala zeera in the cultivated area is around 129 kg ha<sup>-1</sup> which is quite low when compared to 350-400 kg ha<sup>-1</sup> obtained from annual type of zeera (*Carum carvi* L.). Kala zeera seed is a spice / condiment of very high value (Rs.6,000-7000 kg<sup>-1</sup>). Commonly the ripe seeds are used as a spice to add flavour to the dishes, delicacies and packed foods. It is also used as a flavouring ingredient in breads, biscuits, cakes, cheese, pickles etc. The oil derived from the seeds is used in perfume industries and in many ayurvedic medicines. High quality beverages are also made from the seeds in the developed countries. Moreover there is almost complete deficiency of literature in genetic and genomic assessment. No work has been reported on its conservation, domestication, genetic improvement/ breeding, development of package for scientific cultivation, production and propagation. The plant although being economically very important in the state and entire north-west Himalayan region, its domestication and production has received less focus. For this high valued low volume cash crop species genetic variability in the form of land races exists in some specific higher areas like Gurez valley in the J&K State. In the recent past continuous unscientific and ruthless exploitation of this crop by locals of these areas for immediate financial gains has led to low productivity and genetic erosion of land races. If this situation is not taken care of, the crop area may soon become drastically reduced which may, ultimately, lead to heavy economic losses or crop may become extinct. Concerted efforts on part of the government and scientists are imperative for speedy redressal of this problem so as to save this valuable cash crop from being wiped out from the state. Gurez is the most important Kala zeera growing area which harbours various sub-populations within its forest pockets which possess significant genetic variability. By far, the forest areas of Gurez contribute maximum to the zeera production of the state and as such judicious domestication of this crop in this area for commercial cultivation will significantly contribute in efficient utilization of the genetic resources available in this crop species so as to enhance its production and productivity. Recently, there are some reports of zeera cultivation by farmers in states of Himachal Pradesh and Uttarakhand. In addition, there is no report available regarding systematic collection of Kala zera landraces from different hot spots in Kashmir valley and their morphological and molecular characterization using reliable genomics tools. Evaluation

of genetic diversity is a prerequisite for identifying the suitable genotypes in a crop, which can be utilized further for initiation of breeding and other improvement programmes. The breeding programmes can then lead to the identification of elite genetic stocks that could be recommended for commercial cultivation. During the present study, efforts will be made to collect, characterize and conserve Kala zeera from different hot-spots in Jammu and Kashmir. This will be the first report for systematic characterization of Kala zeera from north-western Himalayas. The study is as such proposed keeping in consideration the need to collect, conserve, characterize, domesticate and popularize the zeera crop cultivation in Gurez valley.

## **1. INTRODUCTION**

### **2.1. Background of the Project**

*Bunium persicum* (Bioss) belongs to the *Apiaceae* family and is an important medicinal and aromatic herb. It is a low volume, high value ethano-medicinally important herbaceous species widely used for culinary, flowering, perfumery and carminative purposes (Pourmortazavi *et al.* 2005). It grows wild in the dry temperate regions of Central Asia, including India, Iran, Egypt, Pakistan, Afghanistan and Kazakhstan (Panwar, 1992). In India, *B. persicum* grows wild in alpine and sub-alpine habitats of north-west Himalayan states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Gurez is one of the most important kala zeera growing area in the Union Territory (UT) of Jammu and Kashmir, which is thought to harbour various sub-populations within its forest pockets possessing significant variability for this crop (Khan *et al.*, 2022). This variability has been observed in the form of land races that exist in higher reaches of Gurez valley. In the recent past continuous unscientific and ruthless exploitation of this crop by locals of these areas for immediate financial gains has led to low productivity and genetic erosion of this crop. The drastic reduction in area in this way under this crop has further aggravated the situation. If this situation is not taken care of, the crop area under Kala zeera may soon become drastically reduced which may, ultimately, lead to heavy economic losses or extinction of this spice. By far, the forest areas of Gurez contribute maximum to the zeera production of the UT and as such judicious domestication of this crop on scientific lines in this area for commercial cultivation is expected to contribute significantly. Further the efficient utilization of the genetic resources available in this crop species could be initiated through breeding by means of establishment of a kala zeera germplasm bank. The domestication of this crop on scientific lines and establishment of diverse germplasm bank in kala zeera have potential to contribute in enhancement of production and productivity and initiation of a full-fledged plant breeding programme for genetic improvement of Kala zeera in this area. Such issues could be well addressed through implementing partners and representatives of tribal communities of Gurez under the technical support and guidance of SKUAST-Kashmir.

## **2.2. Overview of the Major Issues to be Addressed** (max. 500 words)

Overexploitation and lack of scientific interventions over time has resulted in a substantial decline of Kala zeera in north-west Himalayan states of Jammu & Kashmir, Uttarakhand and Himachal Pradesh regions of India. Further, for the propagation of this spice plant requires 4-6 months for seed to germinate under cold in its native settings, and the crop may be harvested only after 3 years of seeding. This long duration of seeding has been identified as a barrier to its commercial cultivation through seed. The tribal people often lift the immature seeds from hills for their immediate financial benefits resulting in the restriction of its propagation (Khan *et al.*, 2022). The propagation through tubers is the only way forward which demands availability of enormous zeera tubers for multiplication and its further area expansion. Less seed viability, non-availability of quality tubers and long seed to seed cycle has resulted in decline in area and production of this commercially and medicinally significant spice plant in its native habitats. The plant breeding and biotechnological interventions and conservation strategies are needed to conserve this valuable plant species. Our efforts under the project are expected to domesticate this crop on scientific lines and help to conserve useful genetic diversity of kala zeera in national/local gene banks for their further redistribution among breeders/farmers worldwide.

## **2.3. Baseline Data and Project Scope** (max. 500 words):

The natural population of kala zeera being grown at Mountain Agriculture Research and Extension Station (MAR&ES) SKUAST-K, Gurez possess morphological diversity that needs to be phenotyped, further it becomes important to characterize and map such diversity across different kala zeera growing areas of Gurez valley. The present investigation is directed at exploration of kala zeera growing areas of Gurez valley to collect the available diversity and to establish these accessions at MAR&ES, Gurez in the form of a Kala zeera Germplasm Bank. The efforts are needed through awareness programmes to educate the local population for stopping harvesting of immature zeera. In order to promote domestication of this crop in Gurez, training programmes need to be conducted to produce quality tubers, to demonstrate cultivation of kala zeera on scientific lines to promote its production and productivity, value addition to promote marketing and characterization of collected accessions through DNA fingerprinting to justify their diverse genetic base.

## **2.4. Project Objectives and Target Deliverables** (as per the NMHS Sanction Order)

### **Objectives:**

- To survey for collection of existing of genetic variability, its characterization and evaluation for establishment of germplasm bank.
- To enhance production of quality planting materials (root tubers) for domestication on marginal foothills and in farmer's field for boosting its production and productivity.

- To conduct trainings/ awareness programmes of tribal farmers on “Scientific cultivation of Zeera cultivation and its post-harvest handling and value addition”
- DNA fingerprinting of local Zeera germplasm

**Target deliverables:**

<b>Objectives</b>	<b>Deliverables</b>
<ul style="list-style-type: none"> <li>• To survey for collection of existing of genetic variability, its characterization and evaluation for establishment of germplasm bank.</li> <li>• To enhance production of quality planting materials (root tubers) for domestication on marginal foothills and in farmer’s field for boosting its production and productivity.</li> <li>• To conduct trainings/ awareness programmes of tribal farmers on “Scientific cultivation of Zeera cultivation and its post-harvest handling and value addition”</li> <li>• DNA fingerprinting of local Zeera germplasm</li> </ul>	<ul style="list-style-type: none"> <li>• Collection and conservation of landraces and development of Kala zeera germplasm bank (&gt;3000 Accessions)</li> </ul>
	<ul style="list-style-type: none"> <li>• Registration of collected and characterized zeera landraces with NBPGR, New Delhi.</li> </ul>
	<ul style="list-style-type: none"> <li>• Database on nutritional and medicinal profile of collected accession to identify elite accession</li> </ul>
	<ul style="list-style-type: none"> <li>• Development of package of practices for Kala zeera cultivation for local farmers (100 farmers)</li> </ul>
	<ul style="list-style-type: none"> <li>• Improvement in economy of local poor farmers through training camp (100 farmers)</li> </ul>
	<ul style="list-style-type: none"> <li>• Develop the strategic plan for domesticating the Kala zeera crop on scientific lines</li> </ul>
	<ul style="list-style-type: none"> <li>• Develop 05 knowledge products: 01 Policy manual document, 01 package, 01 success story and 2 publications in well reputed journal</li> </ul>

### **3. METHODOLOGIES, STRATEGY AND APPROACH**

#### **3.1 Methodologies used :**

##### **A. Seed and planting**

Tubers of around 930 accessions collected during survey of different Kala zeera growing areas (Appendix-1) were established at SKUAST-Kashmir, Gurez (longitude – 34°39 19.822°N, latitude – 74°41’23.087°E) in augmented block design (ABD) with spacing of 30 × 20 cm. Out of these, a core set of 252 diverse Kala zeera accessions was established on the basis of their morphological characterization for yield and yield attributing traits.

##### **B. Morpho-agronomic characterization**

The entire set of Kala zeera accessions were evaluated for different agro-morphological and quality traits (Appendix-2) at MAR&ES Gurez and Molecular biology laboratory at Faculty of Agriculture, SKUAST-K, Wadura during the year 2020-21. The establishment of genetically

diverse stocks (Appendix-2) as selection of elite land races (252 accessions) was done based on morphological data and quality parameters, that constituted a Kala zeera Germplasm

### C. Seed characterization

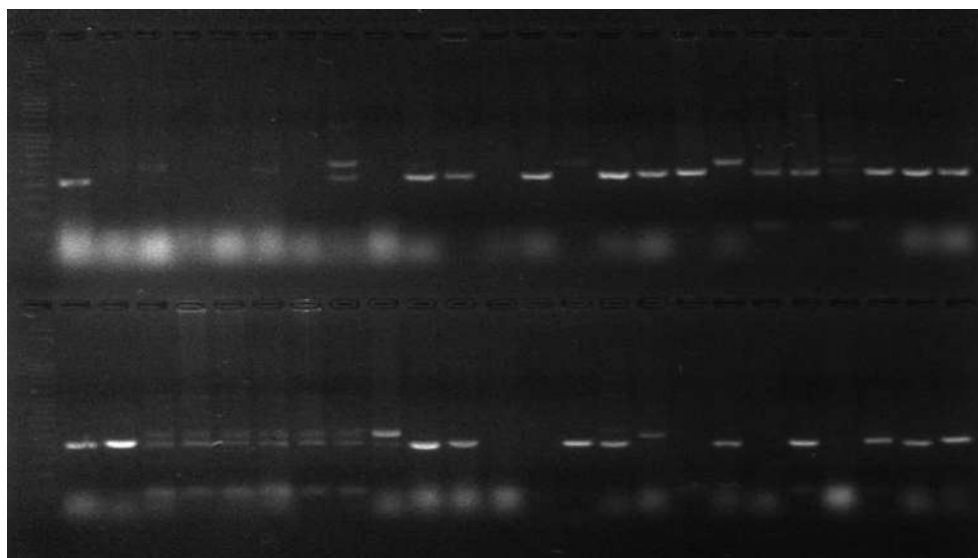
The analysis of the raw data recorded from seed characterization (Appendix 2 & 8) using Image-J software revealed significant diversity for seed length, breadth, size (feret) and area (perimeter) and out of this data, accessions viz., KZG104, KZG120, KZG123, KZG127, KZG126 and KZG134 with superior seed traits were identified.

### D. Estimation of total protein content in 252 diverse lines

The biochemical studies involved estimation of total Protein (Appendix-2 & 8) from 252 diverse collections using methanol extraction method as described by Das *et al* (2014). The principal component analysis demonstrated diverse protein content across 252 accessions. The study identified five accessions viz., **KZG4** (4.640mg/ml), **KZG114** (4.535 mg/ml), **KZG3** (4.4325 mg/ml), **KZG9** (4.3325 mg/ml), **KZG30** (4.3325 mg/ml) with highest protein content.

### E. Molecular characterization of Kala zeera accessions

For molecular characterization of 252 kala zeera accessions, the total genomic DNA was isolated from leaf samples collected from each accessions using CTAB method as proposed by Saghai-Marooof *et al.* (1984). The quality and quantity of DNA (see Figure) was tested using standard procedures.



Quantification of isolated DNA from Kala zeera accessions

From the recently published literature (Bansal *et al* 2022) on development of genomic SSRs in Kala zeera, around 55 SSR primer sequences have been selected on the basis of PIC value, for establishment of diversity across kala zeera accessions. In total fifty-five primers were ordered for synthesis from Sigma-Aldrich, Bangalore. The primer sequences were diluted in Tris-EDTA

buffer solution for making primer stocks and later further diluted to appropriate working concentrations using double distilled water.

For PCR amplification (refer table) DNA concentration of each sample was adjusted to 25 ng/μl by dissolving required quantities of DNA in a fixed volume of sterile double distilled water. *In vitro* amplification using polymerase chain reaction (PCR) Mastercycler No. 5333 48451, 2-6A, 230V, 50-60Hz, 500W from Eppendorf AG 22331, Hamburg Germany (eppendorf@eppendorf.com) was performed in a 20 μl reaction mixture containing 2 μl of genomic DNA samples (25 ng/μl), 2 μl primer (5μM), 0.2 μl of Taq polymerase, 4 μl of 2.5 mM dNTPs and 2.5 μl of 10X Taq buffer (100mM tris pH 9.0, 15 mM MgCl<sub>2</sub>, 500 mM KCl and 0.1% gelatin). The solution was over laid with one drop of low molecular weight mineral oil (Sigma). Amplification was performed using an Eppendorf mastercycler profile detailed.

**Table- Composition of PCR mixture**

Component	Stock concentration	Volume used (μl)	Final concentration
Taq buffer	10X	2.5	1X
dNTP mix	1 mM	2.0	0.2 mM
Primer	5 μM	2.0	0.4 μM
DNA template	25 ng/μl	2.0	50 ng
Taq	3U/μl	0.2	1 unit
Sterilized H <sub>2</sub> O	-	11.3	-
Total	-	20.0	-

### **Preparatory Actions and Agencies Involved:**

Two implementing agencies were involved in this project:

1. SDAO, Department of Agriculture, Gurez and bullock presidents (punch/ surpanch) were involved in providing village wise list of innovative tribal farmers willing to domesticate the kala zeera crop.
2. Range Officer, Department of Forestry, Gurez was involved in survey, identification of hot spots, tagging of plants and collection of tubers.

### **3.2. Data collected and equipments utilized:**

Extensive survey of Kala zeera growing areas (refer table) viz., Nayal, Chorwan, Chuntiwari, Khandyal, Markoot, Dawar, Wanpora & Koragbal villages of Gurez valley and some other

important zeera growing areas of J&K, Himachal Pradesh and Uttarakhand were conducted during years 2019-20, 2020-21 and 2021-22 with the help of project staff. In total around >4000 Kala zeera accessions were collected from different villages and terrains of Gurez valley. The collections were established at Mountain Agriculture Research & Extension Station, SKUAST-K, Dawar, Gurez. The 930 kala zeera collections were established, evaluated and 252 elite and diverse core set was selected, which constituted Kala zeera Germplasm Bank. Morphological diversity of around 252 Kala zeera accessions has been established through Morphological, seed and quality characterization. The collections were established at Mountain Agriculture Research & Extension Station, SKUAST-K, Dawar, Gurez as “Kala zeera Germplasm Bank”. An accession (KZG-301) having distinctive morphological and seed traits as compared to other accessions collected from the area was identified during the survey. The uniqueness of this distinct accession could be an advantage for its exploitation through plant breeding approaches, as this accession has a great potential in exploitation of yield and yield attributing traits in Kala zeera.

**Table- Map location of sites for collection of Kala zeera accessions**

<b>Area</b>	<b>Longitude</b>	<b>Latitude</b>	<b>Altitude (m)</b>
<b>Gurez</b>	34.6494°N	74.7366°E	2,580
<b>Tulail</b>	34.5559°N	75.0544°E	2,750
<b>Kishtiwar</b>	33.3116°N	75.7662°E	1,638
<b>Keran</b>	34.6651°N	73.961°E	1,524
<b>Machil</b>	34.6923°N	74.3592°E	2,450
<b>Tangdhar</b>	34.3975°N	73.8607°E	1,929
<b>Kargil</b>	34.5539°N	76.1349°E	2,676
<b>Paddar</b>	33.2658°N	76.1581°E	2,958
<b>Khrew</b>	34.0209°N	74.9998°E	1,607
<b>Char-e-sharief</b>	33.8629°N	74.7663°E	1,933
<b>Drass</b>	34.4306°N	75.7515°E	3,300
<b>Kinnaur</b>	31.6510°N	78.4752°E	4,075
<b>Lahaul Spiti</b>	32.6192°N	77.3784°E	4,883
<b>Pang</b>	30.0409°N	78.8652°E	4,600
<b>Bharmour</b>	32.4411°N	76.5357°E	2,121
<b>Shong/ Shaung</b>	31.1100°N	77.1600°E	2,662

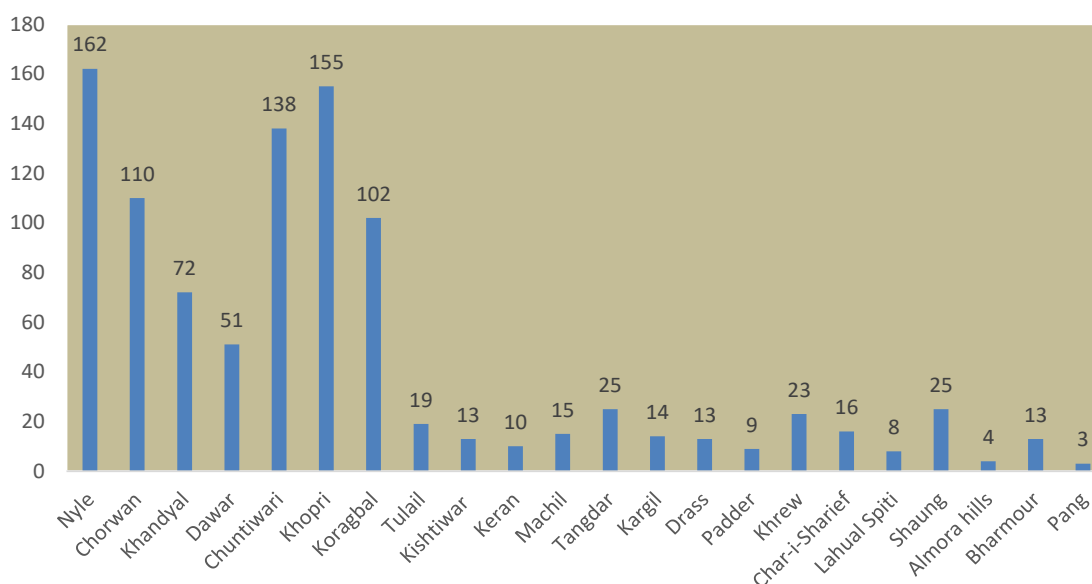


### Equipment used for characterization of Kala zeera accessions:

1. Water bath
2. Centrifuge
3. PCR machine
4. Gel electrophoresis unit
5. Gel documentation system
6. Camera

### 3.3. Details of Field Survey Conducted, if any

The survey route (Appendix-1) consisted of major Kala zeera growing villages of Gurez valley viz., Nyle, Chorwan, Chuntiwari, Khandyal, Markoot, Dawar, Wanpora & Koragbal; other important Kala zeera growing areas of Kashmir valley, Himachal and Uttarakhand were surveyed for identification of genetic variability and tagging of plants. The initial level of character variation was documented along with the spot number with area as reference data. With the help of implementing agencies and local farmers' kala zeera tubers/ seed samples were collected from these areas of Gurez entry-wise during years 2019-20 and 2020-21 for their establishment at MAR&ES, SKUAST-K Gurez. Out of more than 4000 samples collected, only 930 samples could germinate and establish at MAR&ES, SKUAST-K, Gurez. Out of 930 established accessions of Kala zeera, a core set of 252 diverse accessions could be identified on the basis of morphological characterization based on ten yield and yield related traits.



**Major Kala zeera growing areas of Western-Himalayan region of India**

<b>S. No.</b>	<b>Name of the village</b>	<b>Map Location in Gurez</b>	<b>Altitude (meters amsl)</b>	<b>Identification of beneficiaries (Associated local agencies)</b>	<b>Number of Farmers trained under awareness cum training programmes</b>
1	Izmarg	South-West of Gurez	2,367	Surpanch, Department of Agriculture	63
2	Chuntiwari	South-West of Gurez	2,375	Surpanch, Department of Agriculture	74
3	Koragbal	South of Gurez	2,240	Surpanch, Department of Agriculture	45
4	Kanzalwan	South-West of Gurez	2,235	Surpanch, Department of Agriculture	47
5	Nyle	South-west of Gurez	2,752	Surpanch, Department of Agriculture	132
6	Chorwan	North of Gurez	2,710	Surpanch, Department of Agriculture	85
7	Khandiyal	Centre of Gurez	2,470	Surpanch, Department of Agriculture	49
8	Dawar	Centre of Gurez	2,436	Surpanch, Department of Agriculture	38
9	Khopri	Centre of Gurez	2,580	Surpanch, Department of Agriculture	35
10	Achoora	Centre of Gurez	2,550	Surpanch, Department of Agriculture	32

### 3.4 Strategic planning for each activity with time frame

#### **Strategic Planning for each activities:**

##### **3.4.1. *To survey for collection of existing of genetic variability, its characterization and evaluation for establishment of germplasm bank.***

The major Zeera growing villages of Gurez valley viz., Koragbal, Nayal, Tarbal, Chontiwari, Khopri, Chorwan, Khandyal and Wanpora were surveyed during the months of June and July of years 2019-20, 2020-21 for identification of genetic variability and tagging of spots. The initial level of character variation was documented along with the spot number with area as reference data. With the help of implementing partners from line departments viz., Department of Agriculture and Department of Forestry, Gurez, local beneficiaries digging out the zeera tubers was done during the months of September and October each year. The tubers were planted at MAR&ES, SKUAST-K, Gurez in the month of November each year entry wise as per reference data. The entire set of collection of accessions was evaluated for genetic variability through morphological characterization during years 2020 and 2021 that ultimately led to establishment of diverse Kala zeera germplasm bank. Out of which one hundred two (102) characterized entries have been registered with NBPGR, New Delhi (Appendix-6).

##### **3.4.2. *To enhance production of quality planting materials (root tubers) for domestication on marginal foothills and in farmer's field for boosting its production and productivity.***

The root tubers were collected from different areas during October month of years 2019, 2020 and 2021 and were graded and multiplied under domestication and management conditions (tuber-seed cycle) at MAR&ES to produce quality planting material. The local zeera seed was also sown in the month of November during years 2019, 2020 and 2021 for establishment of quality tuber nursery for screening at station. Such quality planting material generated was used for distribution among the beneficiaries in the form of 25 frontline demonstration trials for area expansion in foothills and in farmers field for boosting their production and productivity after its cultivation on scientific lines. A visit to zeera farmers of states of Himachal and Uttarakhand was done in the months of June-July to collect zeera samples (germplasm exchange programme- Appendix-9) from these areas and look for the performance of crop under domestication. The zeera tubers from Gurez were planted at Shaung village and KVK Kinnaur (Appendix 9) but such trials failed after one year of planting.

**3.4.3. To conduct trainings/ awareness programmes of tribal farmers on “Scientific cultivation of Zeera cultivation and its post-harvest handling and value addition”**

With the help of implementing partners from line departments viz., Department of Agriculture and Department of Forestry, Gurez and local administration, 600 tribal people including women and young educated youth from above villages were selected as training (Appendix4) beneficiaries while, 25 beneficiaries were identified on the basis of their willingness, innovativeness and motivation towards work for planting elite Kala zeera accessions as frontline demonstration (FLD) units (Appendix-4). In total 600 beneficiaries were given trainings at MAR&ES, Gurez and awareness programmes (Appendix-4) at their respective villages regarding different agronomic practices and scientific cultivation and post-harvest handling of the crop throughout the years. Those tribal educated youth and women with high motivation and training were used as local channels of motivation for their respective areas.

**3.4.4. Germplasm exchange programme** (Appendix-9) with Himachal Pradesh was taken up with KVK Kinnaur and village-Shaung, The germplasm shared with these centres could not get established in these locations. However, we were successful in establishing collections from Lahual Spiti, Shaung, village of Himachal Pradesh at MAR&ES Gurez, but most of which couldnot germinate in second year of establishment.

Different project activities and sub-activities	Year (2019-20)	Year (2020-21)	Year (2021-22)
<b>Activity1. Survey for collection of existing of genetic variability, its characterization and evaluation for establishment of germplasm bank.</b>			
<b>Sub-activity 1.1</b> Collection of Zeera accessions from hotspots in Gurez valley			
<b>Sub-activity 1.2</b> Survey and tagging of plants with the help of implementing agencies			
<b>Sub-activity 1.3</b> Planting of the Zeera accessions at MAR&ES, Gurez for their evaluation and morphological characterization			
<b>Sub- activity 1.4</b> Agro-morphological trait evaluation			
<b>Sub- activity 1.5</b> Database on nutritional profile of collected accession to identify elite accession			
<b>Sub- activity 1.6</b> Registration of collected and characterized Zeera landraces with NBPGR, New Delhi			
<b>Activity 2. Production of quality planting materials (root tubers) for domestication on marginal foothills and in farmer's field for boosting its production and productivity</b>			
<b>Sub-activity 2.1</b> Development of package of practices for kala zeera cultivation for local farmers (100 ST farmers)			
<b>Sub-activity 2.2</b> Improvement in economy of local farmers through training camp (100 ST farmers)			
<b>Activity 3. Conducting trainings and awareness programmes for tribal farmers: Conservation, domestication and Scientific cultivation</b>			
<b>Sub-activity 3.1</b> Conducting trainings and awareness programmes of tribal farmers with respect to importance of collection and conservation ; develop five (5) knowledge products			
<b>Activity 4. DNA fingerprinting of local Zeera germplasm</b>			
<b>Sub- activity 4.1</b> Isolation of DNA from 252 Kala zeera accessions			
<b>Sub- activity 4.2</b> Molecular characterization of 252 diverse accessions of Kala Zeera using Molecular markers			

## 4. KEY FINDINGS AND RESULTS

### 4.1. Major Activities/ Findings

#### 4.1.1 Morpho-agronomic characterization

Trait phenotyping for eleven (11) morpho-agronomic traits (days to flower initiation, days to 50% flowering, days to full bloom, plant height, number of branches per plant, number of umbels per umbel, umbel diameter, days to 80% maturity, number of seeds per plant, 1000 seed weight and seed yield per plant) was done for set of 252 accessions (Appendix 2). An accession having distinctive morphological and seed traits as compared to other accessions collected from the area was identified during survey (Appendix-4). The data on minimum, maximum, mean values and coefficient of variation (CV) for all 11 morpho-agronomic traits was recorded (Appendix-2). The analysis of trait data in augmented block

design (ABD) showed significant variation in all traits. The CV values for the traits ranged from 3 to 58.53%. All the traits of Kala zeera under study showed normal distribution except for days to 50% flowering, days to full bloom, days to 80% maturity and umbel diameter (Appendix-2). The highest mean value was observed for number of seeds per plant (110.85) followed by days to 80% maturity (89.66). The highest CV was found for seed yield per plant (58.53) followed by number of seeds per plant (49.84). However, lowest CV (3) was observed for days to 80% maturity. The high CV values could be attributed to diverse areas of collection and difference in plant types. PCA analysis grouped the genotypes into four components (Appendix-2). Component 1 has the major contribution of days to flower initiation (0.455), days to 50% flowering (0.518), days to full bloom (0.501), days to 80% maturity (0.481) to the total variability. Component 2 has the major contribution of number of branches per plant (0.492), number of umbels per plant (0.503), number of seeds per plant (0.530) and seed yield per plant (0.349) to the total variability. Similarly, plant height (0.586) and number of umbelets per umbel (0.658) and plant height (0.584) and seed yield per plant (0.449) have contributed to total variation from components 3 and 4, respectively. Appendix-2 shows the diversity of Kala zeera accessions for seed traits and protein content respectively, while the results of bi-plot analysis for seed traits across set of collections are also presented. Morphological diversity of 252 Kala zeera accessions is shown in the form of a dendrogram (Appendix-2).

**Table- Range, mean, standard deviation and coefficient of variation (CV) for characters under study**

<b>Variable</b>	<b>Min</b>	<b>Max</b>	<b>Mean</b>	<b>Std. Dev</b>	<b>CV</b>
Days to flower initiation	26	42	29.16	2.35	8.05
Days to 50% flowering	36	48	39.77	2.62	6.58
Days to full bloom	48	59	54.72	2.52	4.60
Plant height	12	67	35.54	9.66	27.18
Number of branches plant <sup>-1</sup>	1	6	2.82	1.25	44.32
Number of umbelets umbel <sup>-1</sup>	7	15	11	1.61	14.63
Umbel diameter	8.1	11.9	10.3	1.05	10.19
Days to 80% maturity	83	94	89.66	2.69	3.00
Number of seeds plant <sup>-1</sup>	17	347	110.85	55.25	49.84
1000 seed weight	1.56	2.12	1.9	0.11	5.78
Seed yield plant <sup>-1</sup>	0.4	6.4	1.64	0.96	58.53

**Table- Principal component analysis (PCA) of the traits under study**

<b>Variable</b>	<b>PC1</b>	<b>PC2</b>	<b>PC3</b>	<b>PC4</b>
Days to flower initiation	0.455	-0.072	-0.079	0.031
Days to 50% flowering	0.518	-0.101	-0.049	0.056
Days to full bloom	0.501	-0.102	-0.024	0.066
Plant height	0.025	-0.021	0.586	0.584
Number of branches plant <sup>-1</sup>	0.084	0.492	-0.08	-0.028
Number of umbels per plant	0.147	0.503	0.034	0.013
Number of umbelets umbel <sup>-1</sup>	0.015	0.144	0.658	-0.193
Umbel diameter	0.061	0.178	0.297	-0.604
Days to 80% maturity	0.481	-0.064	0.053	-0.109
Number of seeds plant <sup>-1</sup>	0.094	0.530	-0.046	0.057
1000 seed weight	-0.027	0.139	-0.294	-0.175
Seed yield plant <sup>-1</sup>	-0.018	0.349	-0.166	0.449

#### **4.1.2. Molecular Characterization of Kala zeera accessions:**

Characterization of Kala zeera accessions for genetic diversity using SSR markers is essential to select the most diverse accessions for genetic improvement and hybridization, to develop superior accessions as cultivars, maintain genetic integrity of the accessions, conserve accessions for regional use and to explore possible use of Kala zeera accessions in genetics and genomics projects including population structure, gene flow and mapping studies. The aim of this study was to use novel genomic random SSR markers recently developed by Bansal *et al* (2022) to study the genetic variation among and within Kala zeera accessions under study, which mainly represent the accessions with high yield and high nutritive value traits. The specific objective was to characterize 252 morphologically diverse accessions using fifty-five novel genomic SSR markers to establish diversity of these accessions at molecular level and to ascertain whether morphological diversity of accessions coincides with their diversity depicted at molecular level.

#### **Primer selection:**

A set of fifty-five novel genomic SSRs markers were chosen from the study of Bansal *et al* (2022) based on their amplification quality and polymorphism. These SSR markers were selected on the basis of high PIC value and high allele frequency.

#### **SSR marker characterization**

In the present study, molecular characterization of two hundred fifty two (252) Kala zeera accessions was performed by using fifty-five novel genomic SSR markers. For this purpose, the data obtained with the SSR loci were scored on the bases of base pairs. The SSR markers gave recordable amplicons corresponding to the expected lengths. Out of 55 genomic SSRs, 25 were amplified and showed primer specific amplification on our collection of Kala zeera accessions. These 25 SSR markers were polymorphic and resulted in the identification of 31 loci (Appendix-2). The polymorphism is depicted by the number of alleles and polymorphic information content (PIC) value (refer table). The average number of alleles ranged from 2 to 4 alleles while as the PIC value ranged from 0.2 to 0.48.



**Table- Genetic diversity statistics generated by 25 SSR markers on 252 *Bunium* accessions**

<b>S. No.</b>	<b>SSR Marker</b>	<b>PIC value</b>	<b>Number of alleles</b>
1	SSR 3629	0.372	3
2	SSR 154493	0.485	4
3	SSR 4651	0.345	3
4	SSR 173317	0.378	3
5	SSR 55053	0.324	3
6	SSR 5717	0.394	4
7	SSR 952	0.384	4
8	SSR 118	0.375	3
9	SSR 155286	0.3412	3
10	SSR 90646	0.381	2
11	SSR 79460	0.341	2
12	SSR 60597	0.387	3
13	SSR 32451	0.270	2
14	SSR 23508	0.254	2
15	SSR 24977	0.312	3
16	SSR 3206	0.287	2
17	SSR 231	0.305	2
18	SSR 7749	0.335	2
19	SSR 176801	0.347	3
20	SSR 19659	0.311	3
21	SSR 5041	0.288	2
22	SSR 139114	0.314	3
23	SSR 93997	0.307	3
24	SSR 141689	0.200	2
25	SSR 147579	0.292	2

### **Cluster analysis:**

The un-weighted neighbour joining (UNJ) dendrogram constructed on the basis of genetic dissimilarity matrix grouped the accessions into three major clusters. The cluster I consists of further two sub clusters A & B. Sub-cluster IA was further sub divided into two clusters, while as sub-cluster IB consists of three accessions. Cluster II was sub divided into two sub clusters A & B. Sub-cluster IIA was sub divided into two clusters and sub-cluster IIB consisted of two accessions. Cluster III was divided into two small sub clusters and consisted in total of six accessions. The grouping pattern of the accessions is given in the Appendix-2. The accessions depicted in the red colour represent accessions with good yield and yield contributing traits (Appendix 5) viz., KZG104 (Nayle), KZG-112 (Nayle), KZG120 (Nayle), KZG123 (Nayle), KZG126 (Nayle), KZG127 (Nayle), KZG134 (Nayle), KZG-192 (Chorwan), KZG-208 (Chorwan), KZG-215 (Chuntiware), KZG-272 (Drass, Kargil) and accessions with good protein content (ranging from 4.3325 to 4.640mg/ml) Viz., KZG3 (Village-Chorwan), KZG4 (Village-Chorwan), KZG9 (Village-Chorwan), KZG30 (Village-Chuntiware), KZG114 (Village-Nayle), while as the accession depicted in green colour represent the morphologically unique zeera accession collected from Dawar, Gurez in District-Bandipora, Jammu and Kashmir. The seed of this distinct accession was outsourced for comparative RNA sequencing with other accessions, for the sequencing data is still awaited. Principal coordinate analysis (Appendix-2) separated the 252 accessions into different groups, which was consistent with assignments generated by UNJ dendrogram (Appendix-2). Most of the accessions were grouped in the upper left and lower left portions of the resulting plot. Here also the red colour accessions have good yield and yield contributing traits while as the green one is the morphologically unique zeera accession. Molecular DARwin cluster analysis showed that zeera accessions collected from different regions of western Himalayas had huge genetic diversity. These accessions completely appeared in the different groups, thus depicting the level of genetic dissimilarity and the variation that can be used for the future breeding programs for selecting the most diverse accessions for different hybridization programs and further genetic or genomic studies.

### **4.2. KEY RESULTS**

- ✓ Exploration of Kala zeera growing areas lead to collection of around >4000 Kala zeera accessions from different villages and terrains of Gurez valley. The collections were established at Mountain Agriculture Research & Extension Station, SKUAST-K, Dawar, Gurez. The 930 kala zeera collections that were well established were evaluated for morphological traits and 252 elite and diverse core set was selected. This diverse core set of

252 entries led to establishment of Kala zeera Germplasm Bank at MAR&ES, SKUAST-K, Gurez.

- ✓ Diversity of around 252 Kala zeera accessions has been established through morphological, seed and quality characterization. The collections were established at Mountain Agriculture Research & Extension Station, SKUAST-K, Dawar, Gurez as “Kala zeera Germplasm Bank”. An accession having distinctive morphological and seed traits as compared to other accessions collected from the area was identified during survey.
- ✓ In molecular characterization of 252 kala zeera accessions using 25 SSR markers, the principal coordinate analysis separated the 252 accessions into different groups, which was consistent with assignments generated by UNJ dendrogram. Most of the accessions were grouped in the upper left and lower left portions of the resulting plot. Here also the red colour accessions have good yield and yield contributing traits while as the green one is the morphologically unique zeera accession. The molecular DARwin cluster analysis showed that zeera accessions collected from different regions of western Himalayas had huge genetic diversity. These accessions completely appeared in the different groups, thus depicting the level of genetic dissimilarity and the variation that can be used for the future breeding programs for selecting the most diverse accessions for different hybridization programs and further genetic or genomic studies.
- ✓ The analysis of the raw data recorded from seed characterization using Image-J software revealed significant diversity for seed length, breadth, size (feret) and area (perimeter). The Kala zeera accessions i.e., KZG120, KZG127, KZG126, KZG123, KZG134, KZG104 were identified as elite accessions with better seed traits as demonstrated by Image J analysis. These elite accessions were submitted for registration (assignment of IC Numbers) to NBPGR, New Delhi and accordingly are being maintained in national germplasm repository with allotted IC numbers (Appendix-5).
- ✓ The biochemical studies involved estimation of total Protein from 252 diverse collections using methanol extraction method as described by Das et al (2014). The principal component analysis demonstrated diverse protein content across 252 accessions. The study identified five accessions viz., KZG4 (4.640mg/ml), KZG114 (4.535 mg/ml), KZG3 (4.4325 mg/ml), KZG9 (4.3325 mg/ml), KZG30 (4.3325 mg/ml) with highest protein content.
- ✓ With the help of implementing partners from line departments viz., Department of Agriculture and Department of Forestry, Gurez and local administration, tribal people including women and young educated youth from above villages were selected as beneficiaries who were identified on the basis of their willingness, innovativeness and motivation towards work. The beneficiaries were given trainings at MAR&ES, Gurez and

through awareness programmes at their respective villages. These programmes gave emphasis on different agronomic practices and scientific cultivation, post-harvest handling and value addition of the crop throughout the years. Those tribal educated youth and women with high motivation and training were used as local channels of motivation for their respective and improved kala zeera accessions in the form of twenty five front line demonstration trials were distributed to those tribal families of Gurez.

- ✓ The accessions KZG112, KZG192, KZG272, KZG208, KZG215 were identified as most promising landraces (Appendix 5) based on their overall performance.

#### **4.3. Conclusion of the Study**

- Under collection and conservation of landraces in total around >4000 indigenous, entries have been collected from different kala zeera growing areas of Gurez.
- Morphological Characterization based on ten traits could identify a set of 252 diverse accessions which led to establishment of a Kala Zeera Germplasm Bank at MAR&ES Gurez. One hundred two (102) diverse accessions were recognized by National Bureau of Plant Genetic Resources, New Delhi and accordingly the accessions were registered with allotment of IC numbers.
- In molecular characterization of 252 Kala zeera accessions using 25 SSR primers revealed confirms the existence of huge diversity among accessions under study, which could be well harvested through initiation of trait specific plant breeding programmes. These accessions completely appeared in the different groups, thus depicting the level of genetic dissimilarity and the variation that can specifically be used for the future breeding programs for selecting the most diverse accessions for different hybridization programs and further genetic or genomic studies.
- Germplasm exchange programme with Himachal Pradesh and Uttarakhand was taken up with KVK Kinnaur and Almora, The germplasm shared with these centres could not get established in these locations. However, we were successful in establishing collections from Lahual Spiti, Shaung, Bharmour villages of Himachal Pradesh at MAR&ES Gurez, but most of which couldnot germinate in second year of establishment.
- In total around 600 tribal farmers have been trained for domestication/ scientific cultivation of Kala zeera crop and 25 frontline demonstration trials were given to selected farmers to initiate domestication of this crop.
- Kala zeera accessions with high nutritional/ medicinal values have been identified.
- The accessions KZG112, KZG192, KZG272, KZG208, KZG215 were identified as most promising landraces based on their overall performance.

- In total, one report, three booklets, two leaflets, one policy document and one success story are already published, two research paper have also been published in International journals of repute.

## **5. OVERALL ACHIEVEMENTS**

### **5.1. Achievements on Project Objectives/ Target Deliverables**

Under collection and conservation of landraces in total around >4000 indigenous, entries have been collected from different kala zeera growing areas of Gurez. Morphological Characterization based on ten traits could identify a set of 252 diverse accessions which led to establishment of a Kala Zeera Germplasm Bank at MAR&ES Gurez. One hundred two (102) diverse accessions were submitted to NBPGR, New Delhi and accordingly the germplasm was registered with allotment of IC numbers (Appendix-6). Germplasm exchange programme (Appendix-9) with Himachal Pradesh was taken up with KVK Kinnaur and Shaung village, The germplasm shared with these centres could not get established in these locations. However, we were successful in establishing collections from Lahual Spiti, Shaung village of Himachal Pradesh at MAR&ES Gurez, However most of such tubers did not germinate in subsequent year. In total around 600 tribal farmers have been trained for domestication/ scientific cultivation of Kala zeera crop. Kala zeera accessions with high nutritional/ medicinal values have been identified. In molecular characterization of 252 Kala zeera accessions using 25 SSR primers significant diversity was revealed through the principal coordinate analysis, which separated the 252 accessions into different groups, which was consistent with assignments generated by UNJ dendrogram, where most of the accessions were grouped in the upper left and lower left portions of the resulting plot and the red colour accessions having good yield and yield contributing traits and the green one as the unique zeera accession were distantly placed. This confirms the existence of diversity among accessions under study. The molecular DARwin cluster analysis also showed that zeera accessions collected from different regions of western Himalayas had huge genetic diversity. The accessions KZG112, KZG192, KZG272, KZG208, KZG215 were identified as most promising landraces (Appendix 5) based on their overall performance. These accessions completely appeared in the different groups, thus depicting the level of genetic dissimilarity and the variation that can be used for the future breeding programs for selecting the most diverse accessions for different hybridization programs and further genetic or genomic studies. In total, one report, two booklets, one package and practice, two leaflets, one policy document and one success story are already published. Two research papers have also been published in journals of repute.

### **5.2. Interventions:**

- One hundred two (102) diverse accessions were submitted to NBPGR, New Delhi and accordingly the germplasm was registered with allotment of IC numbers.

- Twenty five (25) frontline demonstration trials were given to tribal farmers from different villages of Gurez to promote domestication of the crop.
- Five high yielding Kala zeera accessions have been identified which have potential to out yield our present variety Shalimar Kala zeera-1.
- In total, one report, two booklets, one package and practice, two leaflets, one policy document and one success story are already published. Two research papers have also been published in journals of repute.

### **5.3. On-field Demonstration and value addition of products, if any**

In total around 600 tribal farmers have been trained for domestication/ on field scientific cultivation of Kala zeera crop. Beneficiaries were trained for preparation of value added products for which a booklet on “value addition and marketing of Kala zeera” was developed to guide the farmers.

### **5.4. Green Skills Developed in state/ UT**

Village wise campaigns were conducted to promote conservation of zeera crop, samples collected from adjacent areas were established at Gurez in the form of a Kala zeera Germplasm Bank. The 600 tribal farmers have been trained for scientific cultivation of Kala zeera crop, which is expected to promote domestication of crop in the area.

### **5.5. Addressing Cross-cutting issues**

- Overexploitation and lack of scientific interventions over time has resulted in a substantial decline of Kala zeera in north-west Himalayan states of Jammu & Kashmir, Uttarakhand and Himachal Pradesh regions of India. Training of 600 beneficiaries for scientific cultivation of kala zeera and devising package for cultivation of this crop is expected to increase area under domestication for this crop.
- The tribal people often lift the immature seeds from hills for their immediate financial benefits resulting in the restriction of its propagation (Khan *et al.*, 2022). Village-wise awareness programmes in collaboration with implementing partners and local administration and police to stop harvesting of immature crop from hills would definitely help in conservation of this values spice.
- The plant breeding and biotechnological interventions and conservation strategies are needed to conserve this valuable plant species. Establishment of diverse kala zeera germplasm bank at Gurez is expected to pave way for breeding and biotechnological interventions for genetic improvement of this valued spice. Our efforts under the project are expected to domesticate this crop on scientific lines and help to conserve useful genetic diversity of kala zeera in national/local gene banks for their further redistribution among breeders/farmers worldwide.

## 5.6. Publications:

Three knowledge products in the form of two booklets entitled, “Scientific cultivation of Kala zeera in Gurez (Package and Practice)” and “Diversity value addition and Marketing of Kala zeera” and one bulletin entitled, “Conservation of Kala zeera: A heritage crop of Gurez Valley” have been prepared and are being distributed during awareness programmes at Gurez. In addition two folders one entitled “Kala zeera cultivation in Gurez” and other on “Value addition in Kala zeera” are also being distributed in awareness campus, trainings and demonstration programmes under the project.

- a. **Two relevant research papers** entitled published in international journals of repute:

**Year-2022** “Exploration, collection and characterization of Kala zeera germplasm (*Bunium persicum* Boiss. Fedtsch.) from the north-western Himalayas” *Plant Genetic Resources: Characterization and Utilization* 20(1), 1–4 has been published in Plant Genetic Resources: Characterization and Utilization, Cambridge UK [**NAAS rating = 7.08 ; Impact Factor= 1.08**] [**COPY ENCLOSED**]

**Year-2022** “Need for Cultivation and Conservation of Kala Zeera: A Forgotten Heritage Crop of Himalayas” *EC Nutrition* 17.1 (2022): 39-41. Published in E-CRONICON Nutrition Journal. Crawford Street, London W1H 1PJ, United Kingdom. [**Impact Factor= 2.648**] [**COPY ENCLOSED**]

- b. **One project activity report** has been published in Ziraat Times Magazine.

<http://ziraattimes.com/2020/10/gurez-kashmir-the-fairy-land-of-kala-zeera/> [**COPY ENCLOSED**]

- c. **Project activities** have also been featured and telecasted in DD Kashir, KRISHI DARSHAN programme on 11<sup>th</sup> of November, 2021.

The findings of the research were also presented in different National and International conferences in the form of research abstracts, research posters and lead lectures. (**Refer appendics**)

### d. Research Abstracts Presented in International and National Conferences:

- i. **M. Anwar Khan**, R R Mir, Suhail Altaf, Bilal A Bhat, Waseem A Dar, Mudassir A Magrey, M H Khan, Asif Iqbal Qureshi and B A Alie (2021) Marketing “Gurez Zeera” for maximizing economic returns and livelihood security of tribal farmers of Gurez valley. *International Conference on “Saffron and Seed Spices – Innovative Technologies for Sustainable Development “* scheduled to be held on 7-8 November, 2021 at Shere-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar (J&K) India
- ii. **M. Anwar Khan**, R R Mir, Suhail Altaf, Bilal A Bhat, Waseem A Dar, Mudassir A Magrey, M H Khan, Asif Iqbal Qureshi and B A Alie (2021) “Germplasm conservation and molecular characterization for revival of Kala Zeera cultivation in Gurez” . *International Conference on “Saffron and Seed Spices – Innovative Technologies for Sustainable Development “* scheduled to be held on 7-8 November, 2021 at Shere-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar (J&K) India
- iii. **M. Anwar Khan**, R R Mir, Suhail Altaf, Bilal A Bhat, Waseem A Dar, Mudassir A Magrey, M H Khan, Asif Iqbal Qureshi and B A Alie (2021) Increasing market value of Kala zeera through value addition. *International Conference on Saffron and Seed Spices – Innovative*

*Technologies for Sustainable Development scheduled to be held on 7-8 November, 2021 at Shere-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar (J&K) India*

- iv. **M. Anwar Khan**, R R Mir, Suhail Altaf, Bilal A Bhat, Waseem A Dar, Mudassir A Magrey, M H Khan, Asif Iqbal Qureshi and B A Alie (2021) Conducting awareness-cum-training programmes on cultivation of Kala zeera on scientific lines in Gurez". *International Conference on Saffron and Seed Spices – Innovative Technologies for Sustainable Development scheduled to be held on 7-8 November, 2021 at Shere-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar (J&K) India*

**e. Research Poster Presentation in National Symposium:**

- i. **Azra Anjum, M. Anwar Khan**, R R Mir, Bilal A Bhat, Waseem A Dar (2022). Germplasm Conservation and Domestication of Gurez-Zeera Towards Livelihood Security of Tribal Farmers of Gurez. *National Seminar on Recent advances in Science and Technology for Agriculture Sustainability (RASTAS), 5-6 July, 2022, Department of Botany, School of Life Sciences, Central University of Kashmir, Nuner, Ganderbal, Jammu and Kashmir.*
- ii. **Azra Anjum, Mohammad Anwar Khan**, Reyazul Rouf Mir, Safoora Shafi, Sofora Jan, Farkhandah jan, Tahmeena Bano, Bilal Ahmad Bhat, Waseem Ali Dar and Feroz Ahmad Parry (2022) Morpho-agronomical Trait Phenotyping and Diversity in Bunium persicum (Kala zeera) Germplasm from Northwestern Himalayas. *National Seminar on Recent advances in Science and Technology for Agriculture Sustainability (RASTAS), 5-6 July, 2022, Department of Botany, School of Life Sciences, Central University of Kashmir, Nuner, Ganderbal, Jammu and Kashmir.*

**f. Lead Lecture in National Symposium:**

**M. Anwar Khan**, Azra Anjum, R R Mir, Bilal A Bhat, Waseem A Dar (2022) Collection and Evaluation of Indigenous Germplasm of Kala zeera for establishment of diverse germplasm bank and its domestication towards livelihood security of tribal farmers of Gurez. *A Lead Lecture in : National Symposium on Renaissance of Hill Agriculture Through Advanced Genetics and Crop Breeding Interventions for Attaining Food and Nutrition Security under climate change scenario, September 10-12, 2022*

**g. A Policy document:**

*A policy document on: STRATEGIES FOR REVIVAL OF GUREZ- ZEERA TO ENSURE LIVELIHOOD SECURITY OF TRIBAL FARMERS OF GUREZ (2022) was also developed by M. Anwar Khan et al. [COPY ENCLOSED]*

## **6. PROJECT IMPACTS IN IHR**

### **6.1. Socio –Economic Impact:**

The work executed under the project is expected to impact socio economic status of not only tribal farmers of Gurez valley of Jammu and Kashmir, but this work is expected to affect the economic status of Kala zeera growing areas of north western Himalayan states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Under the project:



- Diverse landraces have been collected from three northern states of India and characterized for variability for selection of elite landraces. These selections are expected to play a pivotal role in sustaining the livelihoods of the poor and marginal tribal farmers of these areas.
- Domestication of Kala zeera with motivation for cultivation of the crop on scientific lines is expected to boost production and productivity of this crop.
- The trainings imparted on value addition of Kala zeera are expected to revolutionize the returns and help in economic sustainability of this enterprise.
- The landraces of kala zeera selection for domestication in these areas are nutritionally rich and are expected to exhibit positive impact on food security.
- The project will contribute to the conservation and maintenance of diversity of landraces and as such assist in future kala zeera breeding programmes for development of elite varieties.

### **6.2 Impact on Natural Resources/ Environment In IHR :**

- Due to increasing human need and greed, deforestation is increasing at alarming pace which ultimately has led to serious environmental changes. So, Kala zeera is a traditional crop which has come to the rescue for the protection of environment
- Under the project efforts have been made through village wise campaigns to stop harvesting of immature zeera, as this practice since long has led to decline in area and production of Kala zeera in the state.
- Kala zeera is an important natural resource particularly for tribal Himalayan regions, which can contribute to their economic and agricultural sustainability.

### **6.3 Conservation of Biodiversity Land Rehabilitation in IHR:**

- The Indian Himalayan region is a rich source of plant genetic resources due to its diverse climatic conditions. India's recognition as a 'mega-biodiversity' country derives partly from the Himalayas wherein out of 6000 endemic plant species, 2532 species occur. Conservation and maintenance of indigenous landraces in the form of "Kala zeera Germplasm Bank" executed under the project is an important step towards genetic improvement of this crop.
- Training of tribal farmers for cultivation of kala zeera on scientific lines and distribution of elite landraces with high yield potential in the form of frontline demonstration trials is expected to increase the area under the crop, thereby enhance its production and productivity.
- Under the project 253 diverse accessions were identified, out of which 102 elite accessions/ landraces have been registered in National Germplasm Repository, NBPGR, New Delhi to allow/ promote its use by entire scientific community of the country.

### **6.4 Developing Mountain Infrastructures:**

- Under the project the indigenous landraces have been maintained in the form of "Kala zeera Germplasm Bank". The establishment of diverse germplasm bank is an important step

towards its breeding/ genetic improvement. The entire diversity of the crop present in the area is now well documented.

- The maintained landraces have also been studied for morphological and molecular characterization, nutritional profiling and seed characterization.

## 6.2. Strengthening Networking in State/UT:

The research and local business networking in the state is expected to improve with mapping of local diversity of landraces, training of tribal farmers for scientific cultivation, frontline demonstration and availability of elite landraces.

## 7. EXIT STRATEGY AND SUSTAINABILITY

### 7.1. Utility of Project Findings:

- ✓ The collections were established at Mountain Agriculture Research & Extension Station, SKUAST-K, Dawar, Gurez. The 930 kala zeera collections were evaluated and 252 elite and diverse core set was selected. This diverse core set of 252 entries led to establishment of Kala zeera Germplasm Bank at MAR&ES, SKUAST-K. This could be used for designing future breeding strategies in Kala zeera.
- ✓ The DNA fingerprinting of 252 Kala zeera accessions proved their diversity at molecular level and such their importance and use in future plant breeding programmes could be justified.
- ✓ The elite and diverse accessions identified from the study were conserved for their future use. One hundred two (102) accessions were recognized by national germplasm repository agency NBPGR, New Delhi and were assigned accession numbers. Now breeder in need for improvement of any trait of economic importance can directly get it from NBPGR, New Delhi.

*The efficient ways to replicate the outcomes of the project in other parts of IHR could as such be:*

The collection and conservation campaign for other IHR states (Himachal Pradesh and Uttarakhand) could separately be taken up as in our study most of the accessions collected from outside Jammu and Kashmir could not survive after one year of establishment. For which specific climatic requirement or prolonged chilling or over wintering could be one of the reasons. As such a separate germplasm bank could be established for these areas outside Jammu and Kashmir.

The elite and diverse accessions identified from the study were conserved for their future use. One hundred two (102) accessions were recognized by national germplasm repository agency NBPGR, New Delhi and were assigned accession numbers. Now

breeder in need for improvement of any trait of economic importance in Kala zeera can directly get its reference accession from NBPGR, New Delhi.

**7.2. Identify other important areas not covered under this study needs further attention (max 1000 words)**

- **Chemical characterization and medicinal value:** The trait phenotyping for other important chemical constituents viz., cuminaldehyde (monoterpene aldehyde), p-cymene;  $\gamma$ -terpinene, p-mentha-1, 3-dien-7-al and p-mentha-1,4-dien-7-al, would be imperative in identification of unique set of accessions from germplasm bank and their genotyping studies.
- **Value addition, Marketing and E Marketing:** Cumin seeds have an aromatic odour and bitter taste. It can be used as a condiment and as an ingredient in curry powders, seasonings of breads, cakes and cheese. The value added products like zeera powder, roasted powder, oil, drinks and food product ingredients such as zeera ladoo, zeera goli, zeera roasted powder, zeera sweet, aaloo zeera, zeera poli, zeera chicken, zeera puffs, roasted zeera bread sticks, zeera bhakhri, zeera cookie, zeera cheese pakooda, zeera biscuits and zeera cheese can be prepared from it. This is expected to give employment to tribal youth besides would led to improvement of market for these value added products. These rural youth can establish e-marketing channels for promoting their products outside state and country.
- **Micro-propagation of tubers:** Less seed viability, non-availability of quality tubers and long seed to seed cycle has resulted in decline in area and production of this commercially and medicinally significant spice plant in its native habitats. The propagation of kala zeera through tubers demands availability of enormous zeera tubers for multiplication and its further area expansion. Micro-propagation of tubers through tissue culture could be useful in making available enormous number of tubers for plantation, area expansion and domestication of this vital crop.
- **Identify varieties resistant to Tuber rot:** The Kala zeera tubers often suffer from rot and die due to fungal infection, although chemical fungicides may control this disease but it at the same time adds to the cost of cultivation and may also cause environmental hazard. Breeding tuber rot resistant varieties could thus be economical and environmentally safe and sustainable strategy to combat this disease.
- **Adulteration:** Stop adulteration of Kala zeera through branding and GI tagging of “Gurez zeera” and devise a short hand diagnosis kit for quick detection of adulterants.

### 7.3. Major Recommendations/ Way Forward:

- **Domestication of crop on scientific lines:** Kala zeera needs to be cultivated on scientific lines by the local tribes. This will not only help in conservation of local biodiversity, but will also help in increasing production and productivity of this crop.
- **Release of high yielding varieties:** Evaluation/ screening of genotypes for identification of high yielding and elite accessions is important in sustainability of this crop. High yield would mean high economic returns to the farmer and hence more demand for cultivation of this crop.
- **More emphasis on value addition and marketing:** Zeera seeds have an aromatic odour and bitter taste. It can be used as a condiment and as an ingredient in curry powders, seasonings of breads, cakes and cheese. The value added products like zeera powder, roasted powder, oil, drinks and food product ingredients such as zeera ladoo, zeera goli, zeera roasted powder, zeera sweet, aaloo zeera, zeera poli, zeera chicken, zeera puffs, roasted zeera bread sticks, zeera bhakhri, zeera cookie, zeera cheese pakooda, zeera biscuits and zeera cheese can be prepared from it. This is expected to give employment to tribal youth besides would led to improvement of market for these value added products. These rural youth can establish e-marketing channels for promoting their products outside state and country.
- **Establish Farmers' cooperatives in each village:** To achieve success, each promotion activity should be a group activity. This is possible only when farmers cooperatives are in place. It becomes easy to promote products of choice/ demand, establish contacts with Government agencies and address the issues and difficulties of common farmers when such cooperatives are well established in an area.

### 7.4. Replication/ Upscaling / Post-Project Sustainability of Interventions:

The major recommendations for sustaining the outcome of project in future include:

- In the long term this project will help in enhancing the socioeconomic impact of farming community that will be associated with cultivation of Kala zeera
- The importance of Kala zeera landraces their conservation and utilization will be increased through plant breeding interventions and release of varieties with high yield, disease resistance and nutritionally rich potential.
- Zeera seeds have an aromatic odour and bitter taste. It can be used as a condiment and as an ingredient in curry powders, seasonings of breads, cakes and cheese. The value added products like zeera powder, roasted powder, oil, drinks and food product ingredients such as zeera ladoo, zeera goli, zeera roasted powder, zeera sweet, aaloo zeera, zeera poli, zeera chicken, zeera puffs, roasted zeera bread sticks, zeera bhakhri,

zeera cookie, zeera cheese pakooda, zeera biscuits and zeera cheese can be prepared from it. This is expected to give employment to tribal youth besides would led to improvement of market for these value added products. These rural youth can establish e-marketing channels for promoting their products outside state and country.

- Group activities are possible only when farmers cooperatives are in place. It becomes easy to promote products of choice/ demand, establish contacts with Government agencies and address the issues and difficulties of common farmers when such cooperatives are well established in an area.

## 8. References/ Bibliography

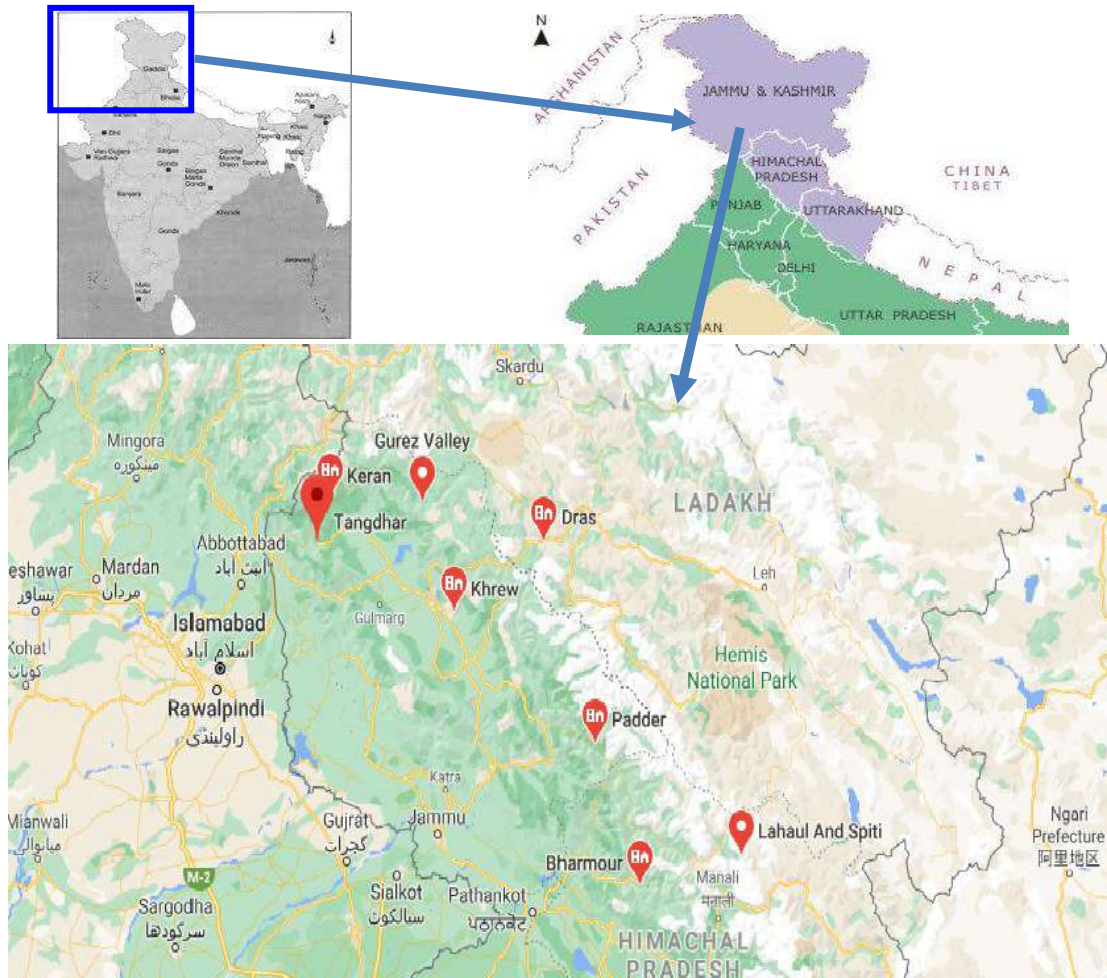
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## **9. ACKNOWLEDGEMENTS**

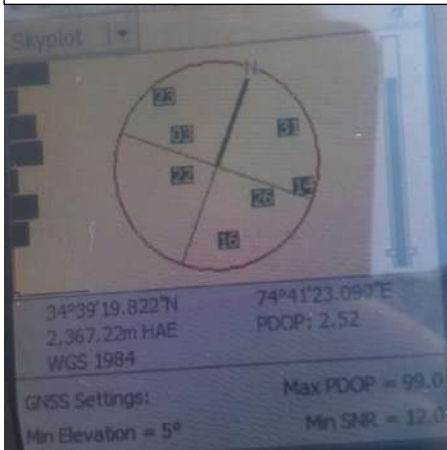
We express our sincere gratitude to National Mission on Himalayan Studies and Ministry of Environment, Forest & Climate Change (MoEF&CC), New Delhi for funding this small grant research project. At the same time, we appreciate the efforts of our implementing agencies viz., Department of Agriculture and Department of Forestry, Gurez during survey and collection in identifying the localities for collection of germplasm. The favour extended by Head, KVK, Kinnaur (H.P) and village Sarpanch, Shaung in germplasm exchange and testing is greatly acknowledged. Our sincere thanks are also due to Director, National Bureau of Plant Genetic Resources (NBPGR), New Delhi for registration of 102 elite landraces in their plant germplasm repository. The support of local administration and police of Gurez during campaigning to stop harvesting of immature zeera from hills is duly acknowledged. We also acknowledge the guidance and support of SKUAST-Kashmir administration and accounts staff during the entire period of study.

# APPENDICES

## Appendix 1 – Details of Technical Activities (Survey and collection of landraces)



a. Survey route for Exploration and Collection of Kala zeera accessions



b. GPS Location of Site of Experimentation



c. Map Location of Site of Experimentation

Survey route of exploration and collection (a), site of characterization of Kala zeera accessions (b, c)



Kala zeera plant at Flowering



Layout of Kala zeera trials at  
MAR&ES SKUAST-K Gurez



**Exploration visits to different Kala zeera growing areas of Gurez**



**Appendix 2: Diversity and Morphological characterization of Kala zeera Landraces**



a. Variation in flowering: Axial and terminal flowering; green and pigmented inflorescence



b. Cultivated and wild Kala zeera

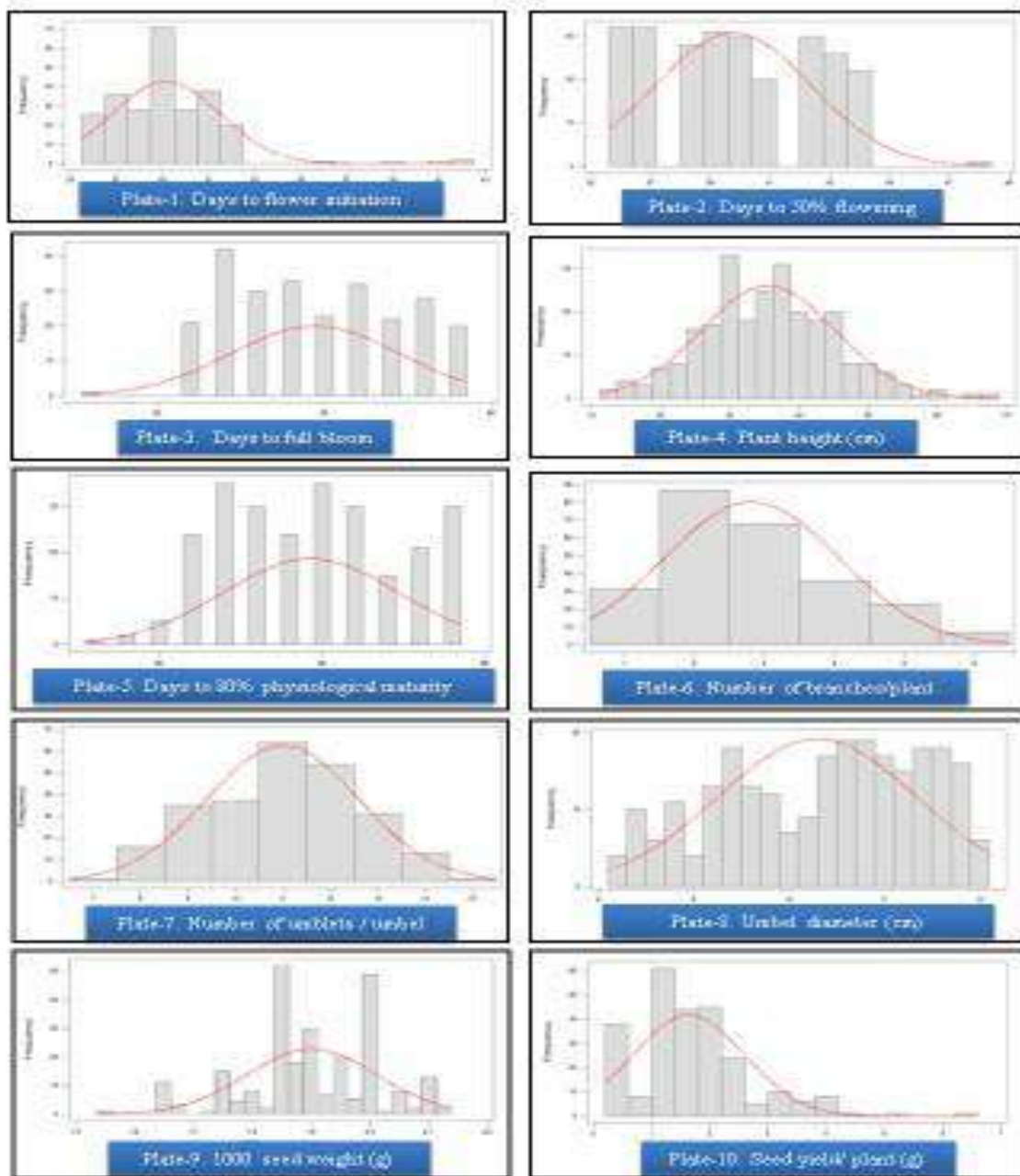


c. Early and late maturing Kala zeera

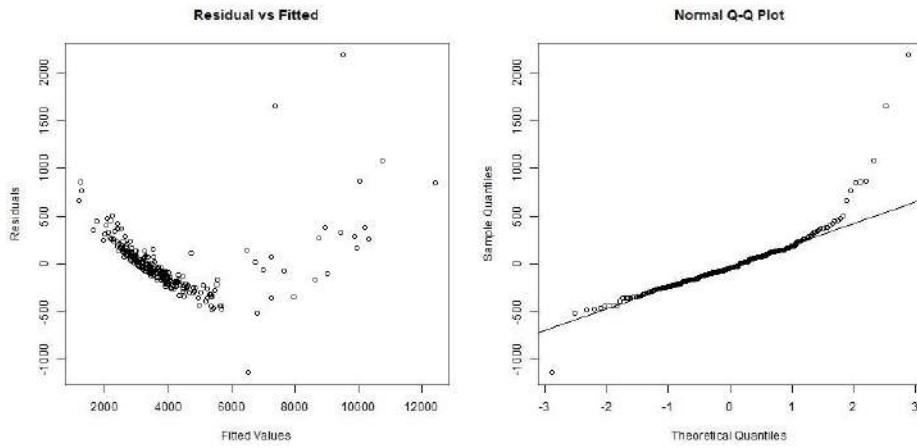


d. Variation in growth habit and branching: indeterminate and determinate

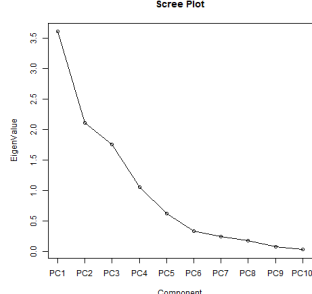
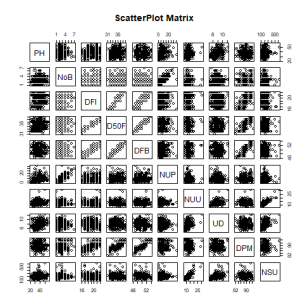
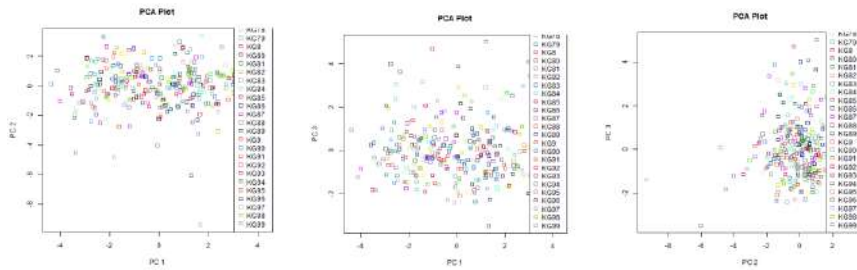
**Variation available for morphological traits in Kala zeera collected from northwestern Himalayas of India**



**Histograms showing distribution of growth trait data (plate 1 to 5) and yield and yield attributing traits (plate 6 to 10)**

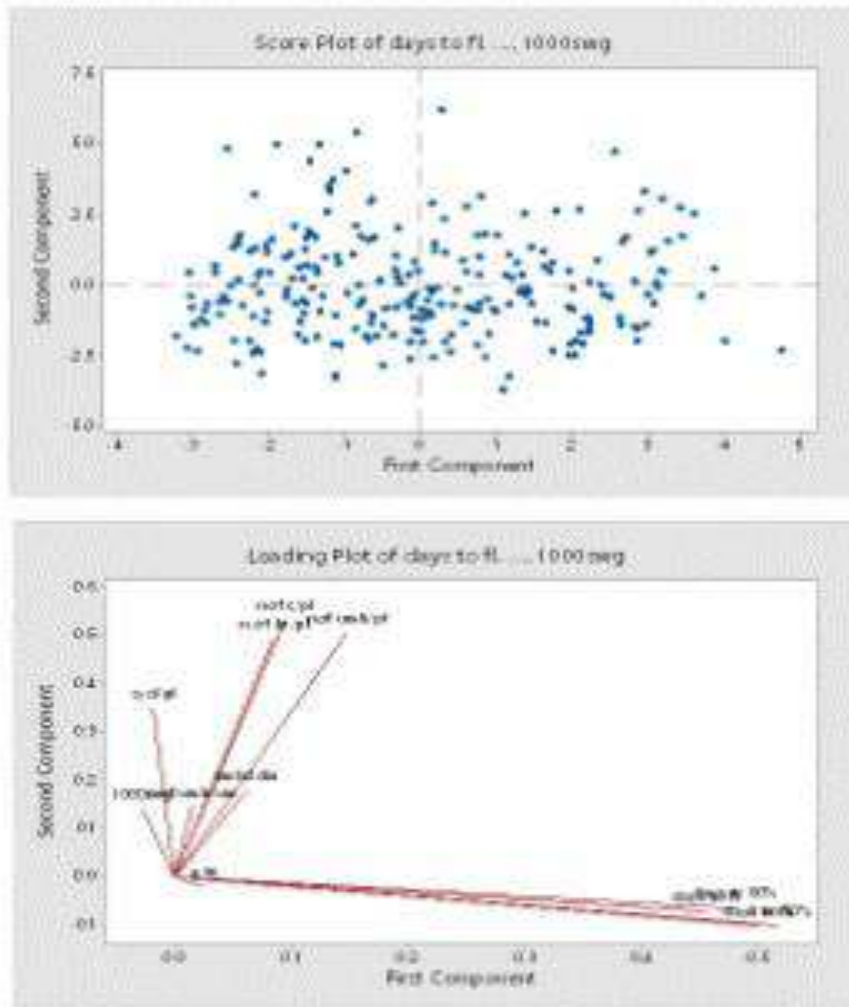


**Diversity Kala Zeera accessions for Seed Traits**

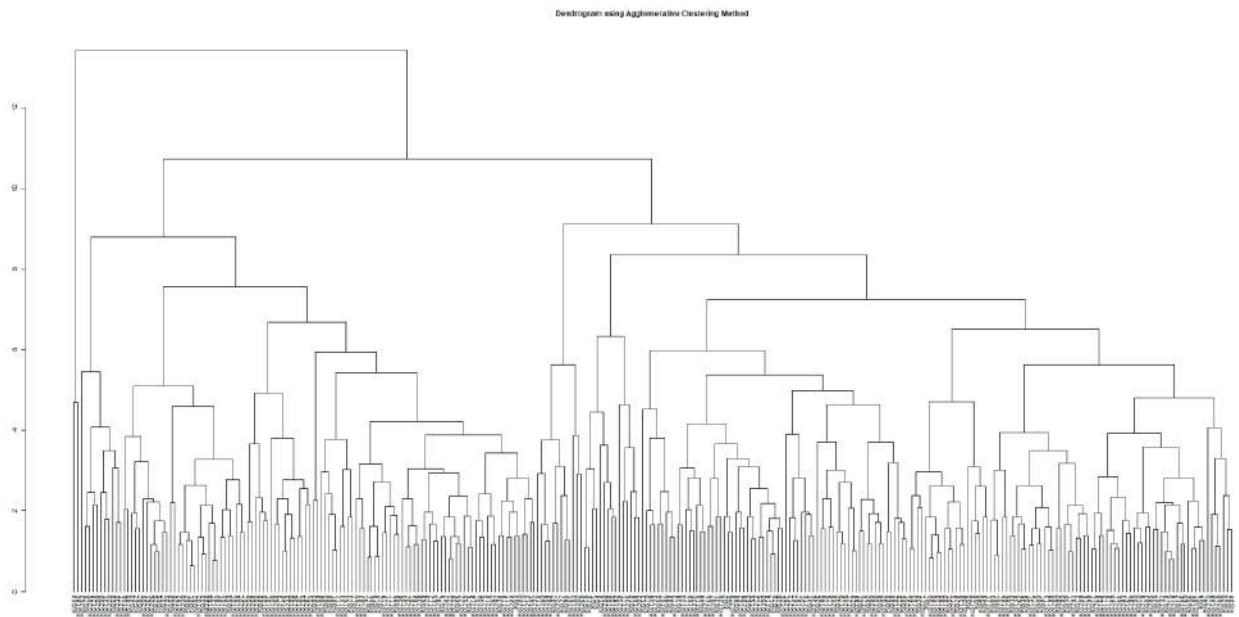


**Principal Component Analysis of Kala zeera accessions depicting diversity for protein content**





**Principal component analysis (PCA)-biplot analysis for seed traits in 252 Kala zeera accessions**



**Dendrogram showing diversity in Kala zeera accessions with respect to protein content using Augmentation Clustering Method**



**Comparison between Unique Kala zeera Accession and Commonly found Kala zeera**



**Image-j analysis of Kala zeera accessions for seed traits**

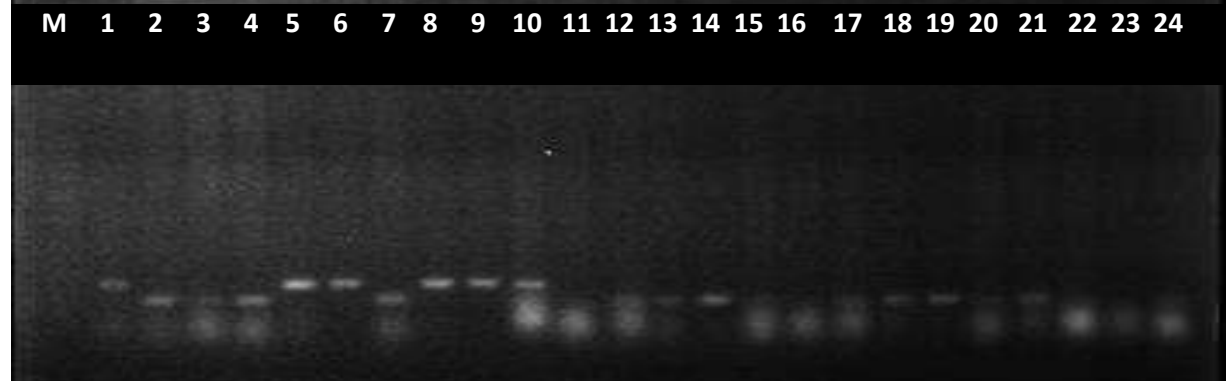


**Estimation of Total Protein content in Kala zeera accessions**

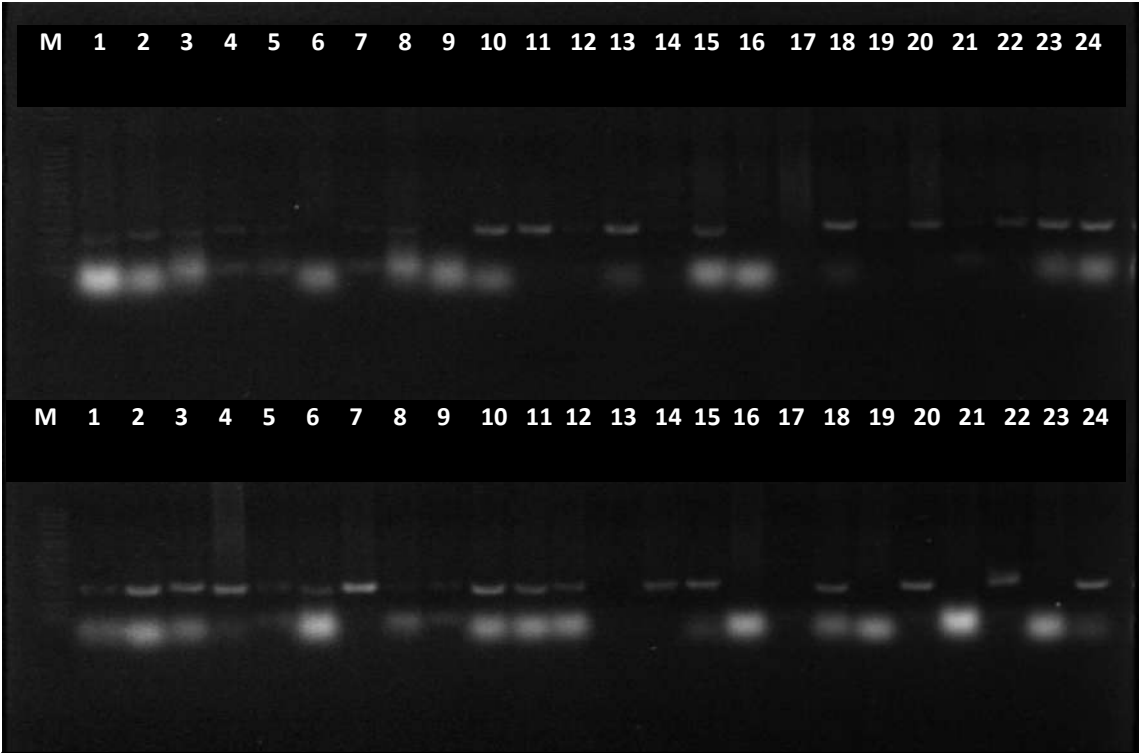




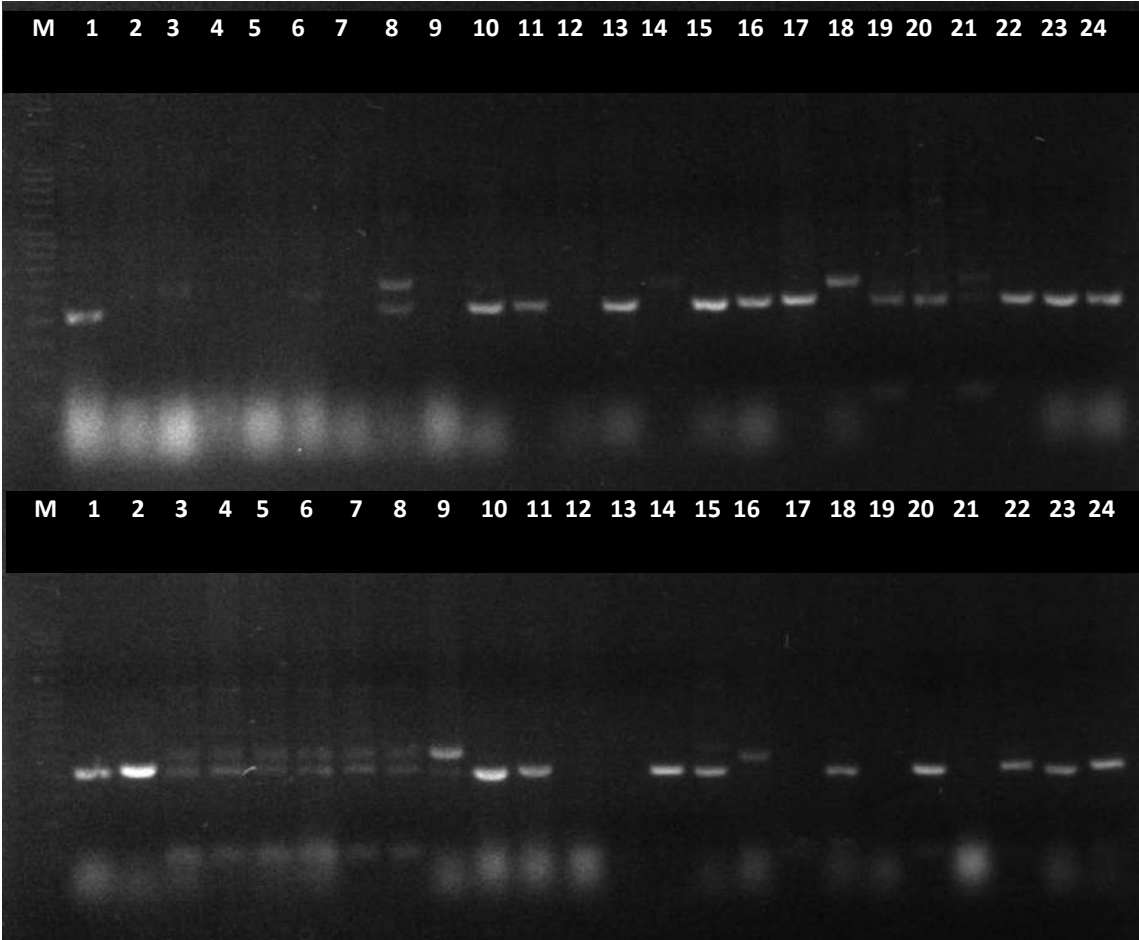
Representative gel picture showing allelic diversity with Primer *SSR4651*



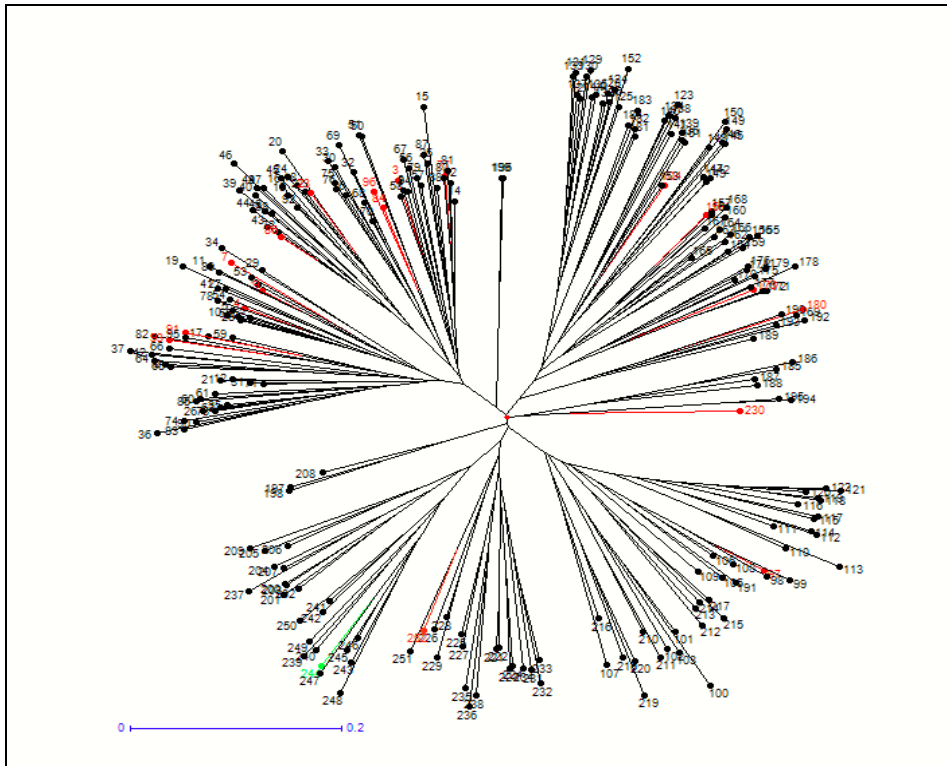
Representative gel picture showing allelic diversity with Primer *SSR3629*



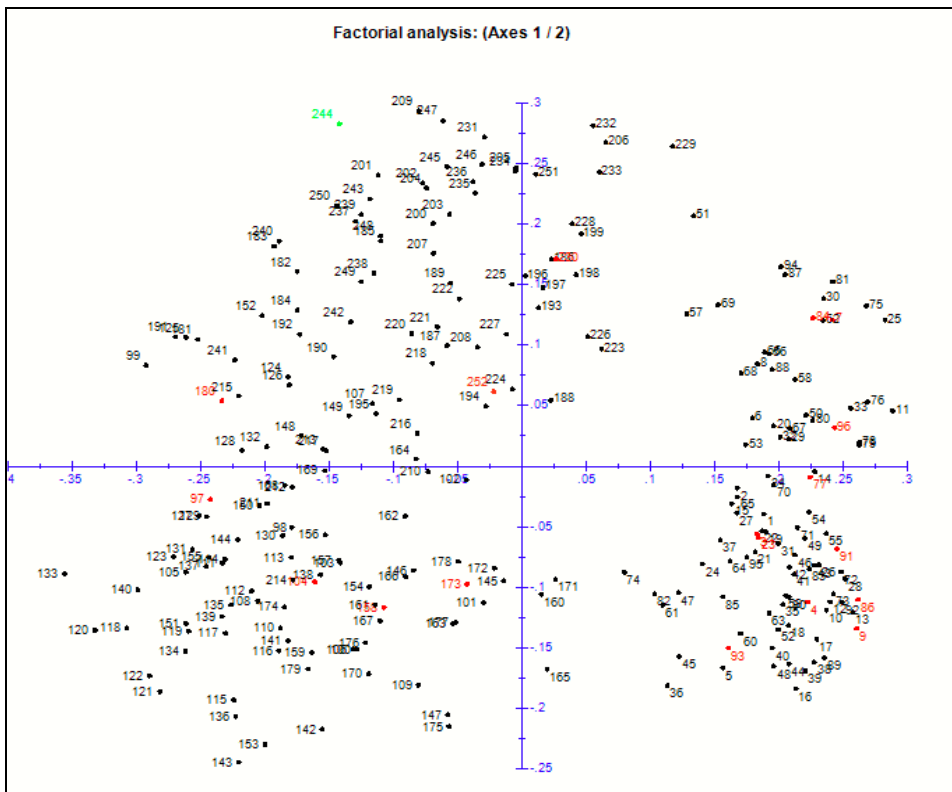
Representative gel picture showing allelic diversity with Primer *SSR90646*



Representative gel picture showing allelic diversity with Primer *SSR55053*



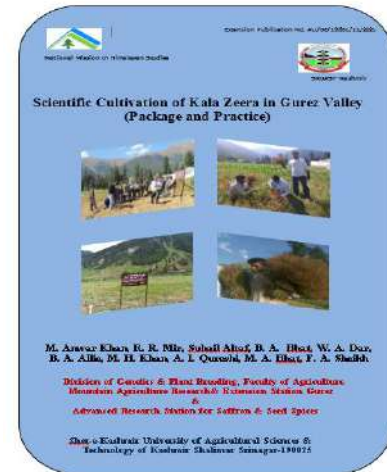
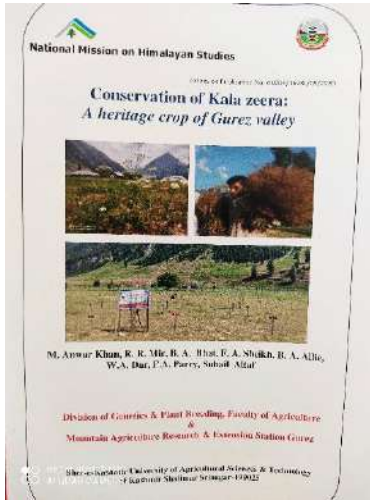
**Neighbor Joining dendrogram generated using 25 SSR markers on 252 Kala zeera Accessions**



**Principal coordinate plot generated by using 25 SSR markers on 252 Kala zeera accessions**

**Appendix 3 – Copies of Publications duly Acknowledging the Grant/ Fund Support of NMHS**

**a. Extension Publications (Booklets, leaflets and Folders etc)**



**Introduction**

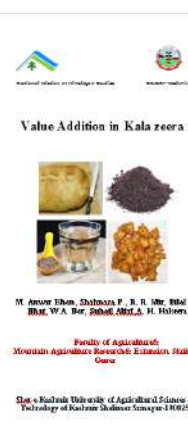
In Jammu and Kashmir, the crop species grows mostly in the wild under natural conditions in forests, open hilly grassy slopes, low alpine and tundra lands as sub-populations, mostly across the hilly areas of Gurez, Tulah, Karan, Ishkhal, Tangdal, Kargil, Kashmir, Paddar, Elberg and Chas-shang. The sub-populations across the state represent a great diversity of this plant species. As per the latest figures of 5th Forest Department, UT of J&K, the average productivity of 'kala zeera' in the cultivated areas is around 129 kg ha<sup>-1</sup>, which is quite low as compared to 330-400 kg ha<sup>-1</sup> obtained from natural type of zeera (*Carum nigrum* L.).

**Cultivation of Kala Zeera on scientific basis**

Kala zeera in Gurez is purely organic. It can successfully be grown under transverse conditions on soils with good organic matter content having high water holding capacity with neutral pH. The success and sustenance is not feasible for the crop, however, since during the months of April and May are favourable for vegetative growth, sowing, formation and seed set. The crop is highly sensitive to moisture stress at flowering stage. Kala zeera can be propagated both through

tubers as well as through seed. Raised beds prepared in the month of October are ideal for planting kala zeera crop using tubers. The land should be ploughed 12-15 cm deep and well decomposed farm yard manure (FYM) or compost @15 to 20 tons ha<sup>-1</sup> should be thoroughly mixed with the soil. For raising vegetative propagules from mature seed, sowing of seed should be done in the month of October @ 10kg/ha.

The recommended planting cycle is of four year duration. After four year tubers should be dug out for subsequent sowing, with spacing of 20 x 20 cm to get maximum seed yield. Zeera tubers (Figure 4) weighing 50g should be sown on for sowing plantation on raised beds to get maximum seed yield/ plant. Seed should be sown 1cm deep to ensure good seedling growth and vigor. Pre-chilling treatment of the seed is necessary for breaking the dormancy (seed being a mesocarp). In order to achieve maximum yields of Kala zeera, maintenance of appropriate plant population (approx. 2.5 lakh plants/ha) is necessary. The recommended plant population is achieved after planting the tubers with row to row spacing of 20 cm and plant to plant spacing of 20cm. Natural herds of Kala zeera on rainfall, when the distribution of rainfall is enough to ensure adequate soil moisture during the crop cycle. However, work domestication the crop may



**Introduction**

Black cumin popularly known as kala or Shaha zeera in the Persian and Indian sub-continent is related variety of regular cumin and is consumed all over the world. Its seeds feature long, slender, curved, dark brown pods with distinctive earthy flavor. Kala zeera is a native ingredient in Kashmir cuisine as well as very popular spice in north Indian cuisine. Black cumin especially popular for its aroma and medicinal properties, is rich in anti-inflammatory antioxidants, and is also known to be antidiabetic and antihypertensive. Cumin seed oil is used in perfumery and for flavoring liquors and conidia. Cumin seeds are also used in various ayurvedic-herbal medicines such as stomach pain, obesity, digestion and dyspepsia. It is also used in the treatment of pain, asthma, insomnia, skin disorders, respiratory disorders, heartburn, common cold, laxation, sinusitis, boils on skin and cancer. Cumin seeds have an aromatic odour and bitter taste. It is used as a



**KALA ZEERA MARKETING IN GUREZ**  
Kala zeera in Kashmir, particularly in Gurez



**RELEASE OF BOOKLETS: PACKAGE AND PRACTICES; VALUE ADDITION OF KALA ZEERA**

## b. Publications (Research papers, Book Chapters, policy document, success stories etc)

### Plant Genetic Resources: Characterization and Utilization

cambridge.org/jgr

#### Short Communication

Journal of Genetic Resources: Characterization and Utilization (2022), Volume 49, Part 1, pp. 1-10. doi:10.1017/S0022267521000001

Received: 14 July 2021  
Revised: 14 July 2021  
Accepted: 14 July 2021

**Key words:** genetic diversity, germplasm, indigenous, medicinal, Kala zeera

**Author for correspondence:** Mohd Anwar Khan, Email: anwar@shaukatkashmir.ac.in

### Exploration, collection and characterization of Kala zeera (*Bunium persicum* Boiss. Fedtsch.) germplasm from northwestern Himalayas

Mohd Anwar Khan<sup>1</sup>, Suhail Ahat<sup>1</sup>, Safara Shafi<sup>1</sup>, Bilal Ahmad Bhat<sup>1</sup>, Waseem Ali Dar<sup>1</sup>, Feroz Ahmad Parry<sup>2</sup> and Reyazul Rouf Mir<sup>1</sup>

<sup>1</sup>SKUAST-Kashmir, Division of Genetics and Plant Breeding, Faculty of Agriculture, P.O. Wadura Campus, Sopore, 190225 Kashmir, India and <sup>2</sup>SKAIST-Kashmir, Mountain Agriculture Research and Extension Station (MAR&ES), Gurez, India

#### Abstract

A study was conducted to collect and characterize the indigenous Kala zeera (*Bunium persicum* Boiss. Fedtsch.) accessions from the hills of northwestern Himalayan states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Around 1000 accessions were collected during the exploration mission, out of which diversity of 252 accessions was established through morphological characterization. The morpho-agronomic characterization and the analysis of trait data revealed significant variability in number of branches per plant, number of tubers per umbel, number of seeds per plant, seed yield per plant and 1000 seed weight. The collection and characterization of these diverse accessions can prove useful in future Kala zeera improvement programmes in the world as this is the first such comprehensive report of the crop from northwestern Himalayan region of India.

#### Introduction

Kala zeera is economically important medicinal spice and perennial herb native to Europe and Western Asia (Zaky et al., 2011). It grows naturally on the hills of northwestern Himalayas of India including Gurez valley at an altitude between 3000 and 3600 m above mean sea level (Bhat, 1987). High altitude regions of Gurez valley, Kashmir; Reas, Madh, Tangdhar, Paddar, Knew, Char-e-Sharad, Dera and Harwan in Jammu and Kashmir; Lahaul spiti, Shyang Pang, Shimour in Himachal Pradesh and Almona hills of Uttarakhand states are important hot spot areas of its production in India (Parwar et al., 1991; Soti et al., 2009; Singh et al., 2011; Makharia and Meek, 2019). High morphological variability has been observed in Kala zeera accessions, but the people from these areas often lift immature plants along with tubers for their immediate benefits. This has restricted propagation of Kala zeera and has also led to its exploitation and genetic erosion. Hence the crop is becoming an immediate conservation concern in northwestern Himalayan hills. The efforts of conservation of genetic resources and breeding interventions could contribute towards enhancement of its production and productivity.

#### Experimental

##### Exploration and collection

Trips were made to systematically collect Kala zeera accessions from its natural habitats across northwestern Himalayas. The exploratory areas covered ~3000 km in northern state of Himachal Pradesh, Uttarakhand and Jammu and Kashmir (Fig. 1 and 2). The altitude of collection sites explored during the present study varied from 1531 to 4865 m above mean sea level (online Supplementary Table S1). The accessions were collected from these areas during years 2016 and 2019 for their establishment and morphological characterization at SKUAST, Kashmir, Gurez.

##### Seed and planting

Tubers of around 1000 collected accessions were planted at SKUAST-Kashmir, Gurez (longitude: 34°59'16.02"N, latitude: 74°41'23.85"E) in augmented block design (ABD) with spacing of 30 x 30 cm. Out of these, 252 diverse (Fig. 5) Kala zeera accessions have been characterized for morpho-agronomic traits at different growth stages.

##### Morpho-agronomic characterization



SKUAST-KASHMIR

NATIONAL MISSION ON HIMALAYAN STUDIES

MOEF

GOVERNMENT OF INDIA

### A policy document on STRATEGIES FOR REVIVAL OF GUREZ- ZEERA TO ENSURE LIVELIHOOD SECURITY OF TRIBAL FARMERS OF GUREZ



Prepared by:-

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Reyazul Rouf Mir  
Azra Anjum  
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Division of Genetics and Plant Breeding, Faculty of Agriculture, Wadura & Mountain Agriculture Research and Extension Station, Gurez

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EC NUTRITION  
Editorial

### Need for Cultivation and Conservation of Kala Zeera: A Forgotten Heritage Crop of Himalayas

Reetika Mahajan<sup>1</sup>, Waseem A Dar<sup>1</sup>, Bilal A Bhat<sup>1</sup>, Farul Gupta<sup>2</sup>, Mohammad Anwar Khan<sup>1</sup> and Sajad Majeed Zargar<sup>1\*</sup>

<sup>1</sup>Protomio Laboratory, Division of Plant Biotechnology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, J&K, India

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*Bunium persicum* (Boiss) Fedtsch., also known as "Black cumini" or "Shahi zeera" or "Kashmiri zeera" or "Himalayan zeera" has 2n = 14 belonging to family Apiaceae is a perennial herb indigenous to the temperate and alpine regions at an altitude of 1050–2100m used in the world. In India, it grows widely in dry and higher regions of Himalayas especially Jammu and Kashmir, Lahaul, Himachal Pradesh, and Uttarakhand [1]. It is one of the earliest spices grown naturally in hills of northwestern Himalayas. Kala Zeera seeds have strong flavor and aroma. Its tubers are also eaten as vegetable in hilly areas of Jammu and Kashmir. According to local farmers of Gurez valley, it is sold for ~7000–11000 rupees for 1 kg. The reason for its higher cost is its wild production. For the same reason it can be called as "Black diamond". In order to save traditional local farmers usually harvest the surplus seeds from the accessions which is the main source of its extinction. As such, it is high time for revival of this important crop for tapping its medicinal potential and upliftment of socio-economic status of people living in these areas.

#### Medicinal value of Kala Zeera

Kala Zeera seeds are rich in essential oil (5–14%) which have antioxidant, antibacterial and antifungal activities. Essential components like cumine anethole (20%), Peranone (14.0%) are also the constituents of Kala Zeera seeds [2–5]. Kala Zeera seeds are mostly used as spice and in culinary. It has stimulant, antispasmodic, expectorant and diuretic properties which can cure a number of diseases like diarrhea, dyspepsia, fever, flatulencia, stomachic, scotting, hemorrhoids, hiccough, hoarseness of voice and numerous other diseases [6–8]. In medical sector, Kala Zeera seeds are mainly used in preparing curative medicines. Its seeds have found to be helpful in regulating cholesterol level, reduce abdominal pain, regulating body temperature, and anemia, reduce immune disorders and cold. It also helps in digestion, helps in relaxing the brain muscles and increases and keeps up certain relaxation in gas, decreases the blood sugar level, assists in lower weight, reduces bad cholesterol, good for the cardiovascular system, enhances lactation.

#### Cultivation and conservation of Kala zeera

Unlike white zeera which is directly grows by seeds every year, Kala Zeera can be produced by two ways i.e. by seed or by tubers. In case of seeds, it cannot directly produce seeds. It takes 3–4 years for the production of tubers which later produce seeds every year. However, if tubers of more than 2g weight are sown directly under proper soil and temperature conditions it will produce zeera seeds every year. It is also noted that the life span of over-tuber is around 8 years after that it is exhausted. Kala Zeera was earlier cultivated by small number of farmers in Jammu and Kashmir. But due to lack of knowledge about this crop and certain diseases which infect it, farmers stopped cultivating zeera since last two decades. Besides, its high commercial utility is remained unexplored and neglected for its cultivation practices and the major portion of the seed produce is harvested extensively from its natural habitats [1].

Now a days, local farmers collect the zeera from the naturally growing habitat. According to the locals, they pick up the whole zeera plant from the hills whenever they go for grazing the animals. This practice leads to the uprooting of the tubers also with the plants. This

Citation: Reetika Mahajan and Sajad Majeed Zargar, et al. 'Need for Cultivation and Conservation of Kala Zeera: A Forgotten Heritage Crop of Himalayas'. *EC Nutrition* 17.1 (2022): 39-41.



### SUCCESSFUL CONSERVATION AND DOMESTICATION MODEL OF GUREZ-ZEERA TOWARDS A SUSTAINABLE TRIBAL AREA ENTERPRISE

A Success Story

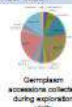


Mohammad Anwar Khan<sup>1</sup>, Azra Anjum<sup>1</sup>, Reyazul Rouf Mir<sup>1</sup>, Bilal Ahmad Bhat<sup>1</sup>, Waseem Ali Dar<sup>1</sup> and Auf Bashir Shikari<sup>1</sup>

<sup>1</sup>SKUAST-Kashmir, Division of Genetics and Plant Breeding, Faculty of Agriculture (FA), Wadura Campus, Sopore, Kashmir

<sup>2</sup>SKUAST-Kashmir, Mountain Agriculture Research and Extension Station (MAR&ES), Gurez

\*Corresponding author: anwar@shaukatkashmir.ac.in

Introduction	Objectives
<ul style="list-style-type: none"> <li>Kala zeera is an economically important medicinal spice and a perennial herb native to Europe and Western Asia</li> <li>It grows naturally on the hills of northwestern Himalayas of India including Gurez valley</li> <li>High morphological variability has been observed in Kala zeera accessions, but the people from these areas often lift immature plants along with tubers for their immediate financial gains</li> <li>This has restricted propagation of Kala zeera and has also led to its exploitation and genetic erosion</li> <li>Hence the crop is becoming an immediate conservation concern in northwestern Himalayan hills</li> <li>The efforts of conservation of genetic resources and breeding interventions could contribute towards enhancement of its production and productivity</li> </ul>	<ul style="list-style-type: none"> <li>Morphological characterization of local Kala zeera germplasm and perform selections on the basis of various morphological, yield and yield attributing traits</li> <li>Establishment of diverse accessions in the form of Kala zeera Germplasm Bank</li> <li>Multiplication of elite Kala zeera accessions for distribution to farmers</li> <li>Promoting scientific cultivation of Kala zeera through farmers' trainings &amp; successful domestication</li> </ul>
Methodology	<ul style="list-style-type: none"> <li>Exploration, collection, characterization of local biodiversity</li> <li>Training tribal farmers for scientific cultivation</li> <li>Promoting domestication through FLD trials</li> </ul>
  	
Achievements	Conclusion
<ul style="list-style-type: none"> <li>Routine practice of harvesting of immature zeera by tribal people was restricted through campaigns and involvement of local administration</li> <li>Village level awareness camps to stop harvesting of Gurez zeera before its full maturity</li> <li>Survey and collection of indigenous Gurez zeera germplasm with an objective to harness its local biodiversity</li> <li>Establishment of Kala zeera Germplasm Bank based on 252 diverse accessions at MAR&amp;ES SKUAST-Kashmir Gurez</li> <li>Identification and multiplication of elite accessions and their distribution to tribal farmers as Front line demonstration (FLD) trials</li> <li>Training of tribal farmers for zeera cultivation on scientific</li> <li>Successful domestication of Kala zeera in Gurez demonstrated through performance of 25 FLDs and adoption of zeera cultivation in kitchen gardens</li> </ul>	<ul style="list-style-type: none"> <li>Restricting the practice of harvesting immature zeera shall allow natural propagation of zeera on hills</li> <li>The successful efforts of scientific cultivation and domestication of zeera are expected to boost zeera cultivation, area expansion and enhancement in zeera production and productivity in Gurez</li> <li>The involvement of women and youth in zeera farming and involvement of public sector in branding, GI tagging and e-marketing of Gurez zeera are expected to revolutionize cultivation of this important spice crop</li> </ul>
Acknowledgement	<p>The authors acknowledge the financial support provided by the National Mission on Himalayan Studies (NMHS), Ministry of Environment, Forests &amp; Climate change, Government of India in the form of a Small Grant research project.</p>

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## ENVIS Bulletin Himalayan Ecology

Vol. 30, 2022

State Name: Jammu and Kashmir  
 Common Name: Common rhododendron  
 Scientific Name: *Rhododendron ponticum*

Dedicated to

Shri Narendra Modi Ji  
Hon'ble Prime Minister of India

CONTENTS:

- Lifestyle for Environment
- Special Report on Reintroduction of Cheetah
- Himalayan Ecology and Environment

State Name: Himachal Pradesh  
 Common Name: Pink rhododendron  
 Scientific Name: *Rhododendron campsonianum*

State Name: Uttarakhand  
 Common Name: Brahma Kamal  
 Scientific Name: *Saussurea cebilata*

**ENVIS CENTRE ON HIMALAYAN ECOLOGY**  
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 (An Autonomous Institute of Ministry of Environment, Forest and Climate Change,  
 Government of India) Kosi-Katarmal, Almora-263 642, Uttarakhand, India

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- Himalayan Ecology and Environment

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#### GERMPLASM CONSERVATION AND DOMESTICATION OF KALA ZEERA (*BUNIUM PERSICUM*) TOWARDS LIVELIHOOD SECURITY OF TRIBAL FARMERS OF GUREZ

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#### RATIONALE

Gurez is one of the most important kala zeera growing areas in the UT of Jammu and Kashmir, which harbours various sub-populations within its forest pockets possessing significant genetic variability for this crop. This genetic variability has been observed in the form of land races that exist in higher reaches of Gurez valley. In the recent past continuous unscientific and ruthless exploitation of this crop by locals of these areas for immediate financial gains has led to low productivity and genetic erosion of this crop. The drastic reduction in area under the crop has further aggravated the situation. If this situation is not taken care of, the crop area may soon become drastically reduced which may, ultimately, lead to heavy economic losses. By far, the forest areas of Gurez contribute maximum to the zeera production of the UT and as such judicious domestication of this crop in this area for commercial cultivation is expected to contribute significantly. Further the efficient utilization of the genetic resources available in this crop species in Gurez for breeding through establishment of a Kala zeera germplasm bank can contribute in enhancement of its production and productivity in the area. SKUAST-Kashmir under NMHS funded project has been training local farmers regarding scientific cultivation of zeera on one hand and simultaneously working on selection of high yielding promising accessions, their multiplication and distribution to tribal community to boost zeera farming in Gurez. Efforts are also on way to restrict zeera adulteration, its branding as organic zeera, and establishment of farmers' cooperatives and e-marketing of zeera that will boost the zeera cultivation in Gurez, improve its marketing and provide more livelihood opportunities to tribal farmers of Gurez.

#### SURVEY AND ESTABLISHMENT OF KALA ZEERA GERMPLASM ACCESSIONS

Extensive survey (Fig. 1) of Kala zeera growing areas (hills & terrains) viz., Nayal, Chorwan, Chunniwari, Khandyal, Markoot, Dawar, Wampora & Koraghal etc villages of Gurez valley was conducted during years 2019-20 and 2020-21 with the help of project staff and local collaborating farmers viz., Department of Agriculture and Department of Forestry, Gurez. In total around 3500 kala zeera germplasm accessions were collected from different villages and terrains of Gurez valley during years 2019-20 and 2020-21, respectively. Out of which

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- G-20 Srinagar events: Security, Grid franchise plan for food-proof security cover
- PHDCCI Kashmir and NCCD plan to hold food chain conference in Kashmir
- J&K Forest Dept launches Annual Forest Boundary Inspection
- PDR passes key resolution highlighting J&K's economic situation, SAARC's peace role, among other issues
- BSF sets action plan for Srinagar approved under National Clean Air Program
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### Gurez, Kashmir: the fairy land of Kala Zeera

3 weeks ago

By: Farooq Ahmed and Sarwan Sheikh

Srinagar: Gurez is like a fairy valley which is nestled in the Himalayas in the extreme north of Kashmir valley, producing innumerable agricultural and medicinal products.

Part of Bandipora district, Gurez Valley is about 123 kms from Srinagar and 86 kms from the Bandipora town. From Srinagar, the trip to this picturesque valley takes

[Gurez, Kashmir: the fairy land of Kala Zeera - Ziraat Times](https://www.ziraattimes.com/news/gurez-kashmir-the-fairy-land-of-kala-zeera)

**Note: Hard copies of all the publications/ literature are attached with the report**

**Appendix 4 – Trainings/ Workshops/ Seminars with details of trained resources and dissemination material and Proceedings**

S.No.	Programe Name	Number of times event organised	Participation/ beneficiaries
1	Training programmes	06	600
2	Awareness Camps	10	200
3	Kala zeera Day	01	60



**Training camps for tribal farmers of Gurez**



**Training camps for tribal farmers of Gurez**



Farmers awareness camp at MAR&ES SKUAST-K Izmarg Gurez



Farmers awareness camp at MAR&ES SKUAST-K Izmarg Gurez



Farmers awareness camp at MAR&ES SKUAST-K Dawar Gurez





**Farmers training camp at MAR&ES SKUAST-K Izmarg Gurez**



**Farmers training camp at MAR&ES SKUAST-K Izmarg Gurez**



**Farmers Awareness camp at MAR&ES SKUAST-K Dawar Gurez**

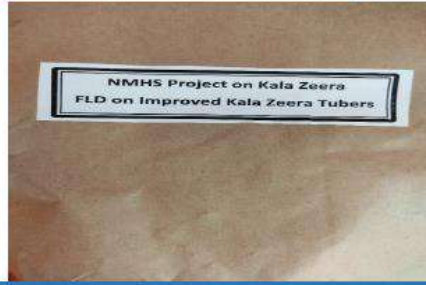


**Farmers awareness camp at MAR&ES, SKUAST-K Dawar Gurez**



**Farmers Training camp at MAR&ES, SKUAST-K Dawar Gurez**

# Kala Zeera Day at MAR&ES Gurez 02<sup>ND</sup> October 2021



**Tribal farmers from different villages of Gurez participated in the programme**



**Twenty-five Kala zeera FLDs were distributed to tribal farmers from different villages of Gurez**



**Distribution of Kala zeera tubers to farmers for front line demonstration under Azadi ka Amrit Mahotsav**



High yielding landraces distributed as demonstration trials



Performance of Kala zeera under domestication



Felicitations of Innovative Farmers for domestication of Zeera



Campaign to stop pre-mature harvesting of zeera from hills



Campaign to stop pre-mature harvesting of zeera from hills





**Monitoring and Performance of Kala zeera Frontline Demonstration trials**



**Performance of Kala zeera Frontline Demonstration (FLD) trials**

**List tribal farmers/ beneficiaries for Kala zeera FLD which are holding Kala zeera FLDs during year 2022**

<b>S.NO</b>	<b>NAME &amp; PARENTAGE</b>	<b>RESIDENCE</b>
01.	Sharif Ahmad Lone S/o Samandar Lone	Izmarg Gurez
02.	Abdul Rehman Wani S/o Ghulam Rasool Wani	Izmarg Gurez
03.	Zahoor Ahmad Lone S/o Ghulam Rasool Lone	Izmarg Gurez
04.	Ghulam Nabi Bhat S/o Sattar Bhat	Naye Basti Gurez
05.	Mushtaq Ahmad Lone S/o Ghulam Mohiddin Lone	Izmarg Gurez
06.	Abdul Gaffar Lone S/o Abdul Rehman Lone	Izmarg Gurez
07.	Azad Ahmad Lone S/o Abdul Gaffar Lone	Izmarg Gurez
08.	Ghulam Nabi Lone S/o Khalid Ahmad Lone	Izmarg Gurez
09.	Mohammad Amin Lone S/o Mohammad Subhan Lone	Jelindoora Gurez
10.	Farooq Ahmad Lone S/o Mohammad Sultan	Jelindoora Gurez
11.	Mohammad Munawar Lone S/o Mohammad Khalil	Kanzalwan Gurez
12.	Mohammad Hussain Chaket S/o Wahab Chaket	Nayal Gurez
13.	Rehana Begum W/o Saleem Baba	Nayal Gurez
14.	Manzoor Ahmad Baba S/o Mohammad Yaseen Baba	Nayal Gurez
15.	Zubaida Begum W/o Zahoor Ahmad Baba	Nayal Gurez
16.	Sumaira Rasool D/o Ghulam Rasool	Nayal Gurez
17.	Javaid Ahmad Baba S/o Abdul Ahad Baba	Nayal Gurez
18.	Tabaya Tahir D/o Tahir Ahmad	Nayal Gurez
19.	Farooq Ahmad Baba S/o Habibullah Baba	Nayal Gurez
20.	Imtiyaz Ahmad Baba S/o Mohammad Shareef	Nayal Gurez
21.	Abdul Nawab Chaket S/o Wahab chaket	Nayal Gurez
22.	Mohammad Anwar Lone S/o Abdul Rahim Lone	Izmarg Gurez
23.	Nasirruddin Lone S/o Shakoor Lone	Achoora Gurez
24.	Wajahat Hussain Lone S/o Mohammad Hussain	Achoora Gurez
25.	Ghulam Rasool Mapnoo S/o Abdul Kabir Mapnoo	Chorwan, Gurez



**Appendix 5. Most promising landraces identified/ selected under the project**



## Appendix 6 – List of trait specific landraces of Kala zeera registered with NBPGR, New Delhi



**National Bureau of Plant Genetic Resources (ARIS Cell) Pusa Campus, New Delhi-110012**

Mission Code :O20210034Z06 National Bureau of Plant Genetic Resources (ARIS Cell)AKMU-7258 IC : 644307 to 644408 Pusa Campus, New Delhi-110012

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**Total 102 Record(s)**

S.No.	Accession Material Type	Coll-No Other-Id	Crop Species	Cultivar Name Bio-Status Variety	Sample Method Sample Type	Collection Date Village/District/State	Source Frequency Habitat	Pedigree Donor	Imp Traits Remark
1	IC-0644307 SEEDS	KZG-3	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	07 Jul 2018 Chorwan /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High Yield
2	IC-0644308 SEEDS	KZG-4	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	07 Jul 2018 Chorwan /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High flavour
3	IC-0644309 SEEDS	KZG-9	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Jul 2018 Chorwan /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High Yield Bushy Growth
4	IC-0644310 SEEDS	KZG-30	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	21 Jul 2018 Chuntiwari /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High Yield
5	IC-0644311 SEEDS	KZG-114	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Nayle /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High Yield
6	IC-0644312 SEEDS	KZG-112	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Nayle /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High flavour and high yield

7	IC-0644313 SEEDS	KZG-215 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Aug 2020 Chuntiwari /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High Yield Bushy Growth
8	IC-0644314 SEEDS	KZG-192 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Aug 2020 Chorwan /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- Good flavour and Black Bold Seeds high yielding
9	IC-0644315 SEEDS	KZG-272 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	19 Aug 2020 Drass /Kargil /Ladakh	WILD FREQUENT WILD	-	- High Yield & Black Bold Seeds
10	IC-0644316 SEEDS	KZG-208 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Aug 2020 Chorwan /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yielding with High flavour
11	IC-0644317 SEEDS	KZG-104 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Nayle /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- Bushy growth, More number of Umbels
12	IC-0644318 SEEDS	KZG-120 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Nayle /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield with More number of Umbels
13	IC-0644319 SEEDS	KZG-123 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Nayle /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield and Bushy growth
14	IC-0644320 SEEDS	KZG-126 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Nayle /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- More number of Umbels
15	IC-0644321 SEEDS	KZG-127 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Nayle /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield and good flavour
16	IC-0644322 SEEDS	KZG-134 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Nayle /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield and Black bold seed
17	IC-0644323 SEEDS	KZG-5 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	07 Jul 2018 Kilshey /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- Pigmented inflorescence
18	IC-0644324 SEEDS	KZG-11 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Jul 2018 Kilshey /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- Branched inflorescence
19	IC-0644325 SEEDS	KZG-15 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Jul 2018 Kilshey /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- Early maturing
20	IC-0644326 SEEDS	KZG-16 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Jul 2018 Kilshey /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- Early maturing
21	IC-0644327 SEEDS	KZG-18 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	16 Jul 2018 Kilshey /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- Profused branching/ bushy growth
22	IC-0644328 SEEDS	KZG-21 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	18 Jul 2018 Burnai /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- Profused branching/ bushy growth

23	IC-0644329 SEEDS	KZG-23 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	18 Jul 2018 Burnai /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Profused branching/ bushy growth
24	IC-0644330 SEEDS	KZG-26 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	19 Jul 2018 Burnai /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Profused branching/ bushy growth
25	IC-0644331 SEEDS	KZG-27 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	19 Jul 2018 Burnai /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Early maturing
26	IC-0644332 SEEDS	KZG-28 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	19 Jul 2018 Burnai /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Early maturing
27	IC-0644333 SEEDS	KZG-29 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	20 Jul 2018 Kilshey /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Early maturing
28	IC-0644334 SEEDS	KZG-32 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	21 Jul 2018 Kilshey /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Branched inflorescence
29	IC-0644335 SEEDS	KZG-34 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	21 Jul 2018 Bhander Koot /Kashtiwari /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Plant Height
30	IC-0644336 SEEDS	KZG-39 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	21 Jul 2018 Bat Koot /Kashtiwari /Jammu and Kashmir	WILD FREQUENT WILD	- -	- More Umbels
31	IC-0644337 SEEDS	KZG-41 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	05 Aug 2018 Kohri /Kashtiwari /Jammu and Kashmir	WILD FREQUENT WILD	- -	- More Umbels
32	IC-0644338 SEEDS	KZG-47 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	05 Aug 2018 Pathgam /Kashtiwari /Jammu and Kashmir	WILD FREQUENT WILD	- -	- More Umbels
33	IC-0644339 SEEDS	KZG-48 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	05 Aug 2018 Keran /Keran /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Umbel Diameter
34	IC-0644340 SEEDS	KZG-53 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Jul 2019 Mundiyan /Keran /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Umbel Diameter
35	IC-0644341 SEEDS	KZG-55 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Jul 2019 Mindiyani /Keran /Jammu and Kashmir	WILD FREQUENT WILD	- -	- High yield with More number of Umbels
36	IC-0644342 SEEDS	KZG-56 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	21 Jul 2019 Pathran /Keran /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Pigmented inflorescence
37	IC-0644343 SEEDS	KZG-57 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	21 Jul 2019 Machil /Machil /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Umbel Diameter
38	IC-0644344 SEEDS	KZG-58 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Machil /Machil /Jammu and Kashmir	WILD FREQUENT WILD	- -	- More Umbels
39	IC-0644345 SEEDS	KZG-60 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Machil /Machil /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Pigmented inflorescence
40	IC-0644346 SEEDS	KZG-62 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Machil /Machil /Jammu and Kashmir	WILD FREQUENT WILD	- -	- More Umbels
41	IC-0644347 SEEDS	KZG-64 -	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Machil /Machil /Jammu and Kashmir	WILD FREQUENT WILD	- -	- Umbel Diameter

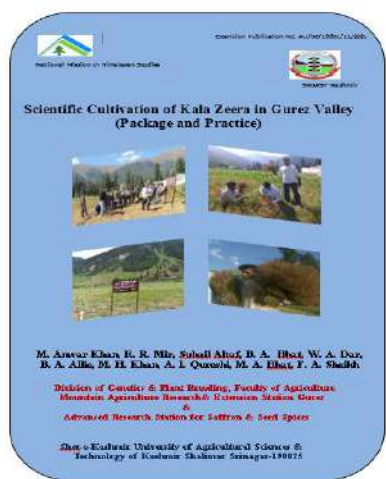
42	IC-0644348 SEEDS	KZG-66	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Machil /Machil /Jammu and Kashmir	WILD FREQUENT WILD	-	- Umbel Diameter
43	IC-0644349 SEEDS	KZG-68	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Mushku /Drass /Jammu and Kashmir	WILD FREQUENT WILD	-	- Bushy growth
44	IC-0644350 SEEDS	KZG-70	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Mushku /Drass /Jammu and Kashmir	WILD FREQUENT WILD	-	- Umbel Diameter
45	IC-0644351 SEEDS	KZG-71	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Pandras /Drass /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield
46	IC-0644352 SEEDS	KZG-72	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Paddar /Kishtiwar /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield with More number of Umbels
47	IC-0644353 SEEDS	KZG-73	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Paddar /Kishtiwar /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield with More number of Umbels
48	IC-0644354 SEEDS	KZG-81	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Paddar /Kishtiwar /Jammu and Kashmir	WILD FREQUENT WILD	-	- Umbel Diameter
49	IC-0644355 SEEDS	KZG-85	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Paddar /Kishtiwar /Jammu and Kashmir	WILD FREQUENT WILD	-	- Plant Height
50	IC-0644356 SEEDS	KZG-88	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Khrew /Pulwama /Jammu and Kashmir	WILD FREQUENT WILD	-	- More Umbels
51	IC-0644357 SEEDS	KZG-89	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	27 Jul 2019 Khrew /Pulwama /Jammu and Kashmir	WILD FREQUENT WILD	-	- High flavour
52	IC-0644358	KZG-90	Black Cumin	-	INDIVIDUAL PLANT	03 Aug 2019	WILD	-	-
	SEEDS		<i>Bunium persicum</i>	WILD	INDIVIDUAL PLANT	Khrew /Pulwama /Jammu and Kashmir	FREQUENT WILD	-	Plant height
53	IC-0644359 SEEDS	KZG-91	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Khrew /Pulwama /Jammu and Kashmir	WILD FREQUENT WILD	-	- Umbel Diameter
54	IC-0644360 SEEDS	KZG-93	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Khrew /Pulwama /Jammu and Kashmir	WILD FREQUENT WILD	-	- More Umbels
55	IC-0644361 SEEDS	KZG-95	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Khrew /Pulwama /Jammu and Kashmir	WILD FREQUENT WILD	-	- High flavour
56	IC-0644362 SEEDS	KZG-98	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Khrew /Pulwama /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield with More number of Umbels
57	IC-0644363 SEEDS	KZG-101	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Khrew /Pulwama /Jammu and Kashmir	WILD FREQUENT WILD	-	- Umbel Diameter
58	IC-0644364 SEEDS	KZG-111	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Khrew /Pulwama /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield with More number of Umbels
59	IC-0644365 SEEDS	KZG-115	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Pukher pora /Budgam /Jammu and Kashmir	WILD FREQUENT WILD	-	- Umbel Diameter

60	IC-0644366 SEEDS	KZG- 116	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Pukher pora /Budgam /Jammu and Kashmir	WILD FREQUENT WILD	-	- Plant Height
61	IC-0644367 SEEDS	KZG- 118	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Forest block /Budgam /Jammu and Kashmir	WILD FREQUENT WILD	-	- More Umbels
62	IC-0644368 SEEDS	KZG- 122	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Forest block /Budgam /Jammu and Kashmir	WILD FREQUENT WILD	-	- High flavour
63	IC-0644369 SEEDS	KZG- 130	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Gund Shamus /Budgam /Jammu and Kashmir	WILD FREQUENT WILD	-	- Plant height
64	IC-0644370 SEEDS	KZG- 131	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Pang /Grehwal /Uttarakhand	WILD FREQUENT WILD	-	- High flavour
65	IC-0644371 SEEDS	KZG- 133	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Pang /Grehwal /Uttarakhand	WILD FREQUENT WILD	-	- High yield
66	IC-0644372 SEEDS	KZG- 136	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Pang /Grehwal /Uttarakhand	WILD FREQUENT WILD	-	- High yield
67	IC-0644373 SEEDS	KZG- 141	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Pang /Grehwal /Uttarakhand	WILD FREQUENT WILD	-	- High yield
68	IC-0644374 SEEDS	KZG- 143	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Pang /Grehwal /Uttarakhand	WILD FREQUENT WILD	-	- High flavour
69	IC-0644375 SEEDS	KZG- 145	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Pang /Grehwal /Uttarakhand	WILD FREQUENT WILD	-	- Umbel Diameter
70	IC-0644376 SEEDS	KZG- 146	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Pang /Grehwal /Uttarakhand	WILD FREQUENT WILD	-	- Plant Height
71	IC-0644377 SEEDS	KZG- 147	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Pang /Grehwal /Uttarakhand	WILD FREQUENT WILD	-	- More Umbels
72	IC-0644378	KZG-	Black Cumin	-	INDIVIDUAL PLANT	03 Aug 2019	WILD	-	-
	SEEDS	150	<i>Bunium persicum</i>	WILD	INDIVIDUAL PLANT	Pang /Grehwal /Uttarakhand	FREQUENT WILD	-	High flavour
73	IC-0644379 SEEDS	KZG- 151	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	30 Jul 2020 Losar /Lahaul Spiti /Jammu and Kashmir	WILD FREQUENT WILD	-	- Plant height
74	IC-0644380 SEEDS	KZG- 152	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	30 Jul 2020 Losar /Lahaul Spiti /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield with More number of Umbels
75	IC-0644381 SEEDS	KZG- 153	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	30 Jul 2020 Losar /Lahaul Spiti /Jammu and Kashmir	WILD FREQUENT WILD	-	- High Yield Bushy Growth
76	IC-0644382 SEEDS	KZG- 157	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	30 Jul 2020 Losar /Lahaul Spiti /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield
77	IC-0644383 SEEDS	KZG- 159	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	30 Jul 2020 Losar /Lahaul Spiti /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield with More number of Umbels

78	IC-0644384 SEEDS	KZG- 161	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	01 Aug 2020 Losar /Lahaul Spiti /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield
79	IC-0644385 SEEDS	KZG- 163	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	01 Aug 2020 Shaung /Kinnaur /Jammu and Kashmir	WILD FREQUENT WILD	-	- High Yield Bushy Growth
80	IC-0644386 SEEDS	KZG- 164	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	01 Aug 2020 Shaung /Kinnaur /Jammu and Kashmir	WILD FREQUENT WILD	-	- More Umbels
81	IC-0644387 SEEDS	KZG- 168	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	01 Aug 2020 Shaung /Kinnaur /Jammu and Kashmir	WILD FREQUENT WILD	-	- High flavour
82	IC-0644388 SEEDS	KZG- 169	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	01 Aug 2020 Shaung /Kinnaur /Jammu and Kashmir	WILD FREQUENT WILD	-	- Umbel Diameter
83	IC-0644389 SEEDS	KZG- 170	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	01 Aug 2020 Shaung /Kinnaur /Jammu and Kashmir	WILD FREQUENT WILD	-	- Plant Height
84	IC-0644390 SEEDS	KZG- 171	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	04 Aug 2020 Shaung /Kinnaur /Jammu and Kashmir	WILD FREQUENT WILD	-	- More Umbels
85	IC-0644391 SEEDS	KZG- 174	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	04 Aug 2020 Shaung /Kinnaur /Jammu and Kashmir	WILD FREQUENT WILD	-	- High flavour
86	IC-0644392 SEEDS	KZG- 175	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	04 Aug 2020 Bharmour /Chamba /Jammu and Kashmir	WILD FREQUENT WILD	-	- Plant height
87	IC-0644393 SEEDS	KZG- 176	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	04 Aug 2020 Bharmour /Chamba /Jammu and Kashmir	WILD FREQUENT WILD	-	- High Yield Bushy Growth
88	IC-0644394 SEEDS	KZG- 178	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	04 Aug 2020 Bharmour /Chamba /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield with More number of Umbels
89	IC-0644395 SEEDS	KZG- 179	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	04 Aug 2020 Khopri /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- More Umbels
90	IC-0644396 SEEDS	KZG- 181	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	10 Aug 2020 Khopri /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High flavour
91	IC-0644397 SEEDS	KZG- 182	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	10 Aug 2020 Chorwan /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield
92	IC-0644398 SEEDS	KZG- 196	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Aug 2020 Chorwan /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High Yield Bushy Growth
93	IC-0644399 SEEDS	KZG- 202	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Aug 2020 Chorwan /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yielding
94	IC-0644400 SEEDS	KZG- 108	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	03 Aug 2019 Chorwan /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yielding
95	IC-0644401 SEEDS	KZG- 172	Black Cumin <i>Bunium persicum</i>	- WILD -	INDIVIDUAL PLANT INDIVIDUAL PLANT	04 Aug 2020 Drass /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield with More number of Umbels

96	IC-0644402 SEEDS	KZG- 255	Black Cumin <i>Bunium persicum</i>	- WILD	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Aug 2020 Shaung /Kinnaur /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yielding, Bushy growth
97	IC-0644403 SEEDS	KZG- 246	Black Cumin <i>Bunium persicum</i>	- WILD	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Aug 2020 Chuntiware /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- Early maturing
98	IC-0644404 SEEDS	KZG- 259	Black Cumin <i>Bunium persicum</i>	- WILD	INDIVIDUAL PLANT INDIVIDUAL PLANT	19 Aug 2020 Khadiyal /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- Bushy growth
99	IC-0644405 SEEDS	KZG- 265	Black Cumin <i>Bunium persicum</i>	- WILD	INDIVIDUAL PLANT INDIVIDUAL PLANT	19 Aug 2020 Khandiyal /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- More Umbels
100	IC-0644406 SEEDS	KZG- 284	Black Cumin <i>Bunium persicum</i>	- WILD	INDIVIDUAL PLANT INDIVIDUAL PLANT	09 Aug 2021 Khandiyal /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High flavour
101	IC-0644407 SEEDS	KZG- 293	Black Cumin <i>Bunium persicum</i>	- WILD	INDIVIDUAL PLANT INDIVIDUAL PLANT	09 Aug 2021 Dawar /Bandipora /Jammu and Kashmir	WILD FREQUENT WILD	-	- High yield with More number of Umbels
102	IC-0644408 SEEDS	KZG- 301	Black Cumin <i>Bunium persicum</i>	- WILD	INDIVIDUAL PLANT INDIVIDUAL PLANT	15 Aug 2021 Dawar /Bandipora /Jammu and Kashmir	WILD RARE WILD	-	- Unique Tall plant stature with profused branching

**Appendix 7 – Copies of the Supporting Materials like Manual of Standard Operating Procedures (SOPs) developed under the project**



A complete package of practice on “**Scientific cultivation of Kala zeera in Gurez valley**” has been developed under the project to promote domestication of crop on scientific lines.



## Appendix 8: Details of data bases generated:

### a. Data base of 252 landraces for ten morphological traits

S.No.	Kala zeera Selection No./ genotype name	Days to flower initiation	Days to 50% flowering	Days to full bloom	Plant height (cm)	Number of branches/plant	No of umbels/plant	No of umbels/umbel	Umbel diameter (cm)	Days to 80% physiological maturity	No of seeds/plant	Seed yield/plant (g)	1000 seed weight (g)
1.	KZG1	30	42	57	38	3	8	9	10.6	88	90	1.8	1.75
2.	KZG2	27	37	52	30	3	8	10	9.2	86	93	2.8	1.94
3.	KZG3	31	43	58	23	2	6	10	9.7	85	50	1.9	1.87
4.	KZG4	28	38	53	40	4	12	11	11.3	89	162	1.9	2.00
5.	KZG6	29	39	55	60	1	5	12	9.4	89	30	2.9	1.88
6.	KZG8	27	38	53	30	5	15	10	11.1	87	215	3.9	2.00
7.	KZG9	29	39	54	17	1	5	11	8.5	92	32	0.4	1.89
8.	KZG10	27	37	52	27	4	11	12	10.8	90	152	0.4	1.92
9.	KZG11	32	44	59	52	2	7	12	9.2	90	70	0.9	1.89
10.	KZG12	26	36	52	27	5	14	10	10.9	84	232	6.4	1.99
11.	KZG13	29	40	54	52	3	8	9	8.7	87	97	1.4	2.00
12.	KZG14	27	38	52	37	5	16	8	11.3	86	252	4.4	2.10
13.	KZG15	30	41	56	47	2	7	9	9.1	88	84	2.9	2.00
14.	KZG16	31	42	58	30	2	6	8	8.9	86	53	1.4	1.74
15.	KZG17	28	38	54	53	4	13	11	10.9	85	183	3.9	1.89
16.	KZG19	29	40	55	15	3	9	11	8.7	90	107	1.9	1.88
17.	KZG20	29	39	54	38	2	7	8	9.6	91	79	2.9	2.00
18.	KZG23	28	39	53	35	3	9	11	9.6	87	101	0.9	1.87
19.	KZG24	29	39	54	56	1	6	9	8.3	88	47	1.9	2.00
20.	KZG25	31	42	57	28	3	11	10	10.6	92	142	2.4	1.94
21.	KZG26	29	40	56	43	3	9	11	9.5	90	103	2.4	1.90
22.	KZG27	29	39	55	24	4	13	11	11.0	90	197	3.9	2.12
23.	KZG30	30	41	56	51	1	6	9	8.6	85	49	2.4	2.00
24.	KZG32	29	40	54	30	3	10	11	10.5	89	113	1.4	1.93
25.	KZG33	29	39	55	38	1	2	8	8.1	88	30	1.9	1.74
26.	KZG34	30	42	56	53	2	7	9	9.3	83	83	2.4	1.96
27.	KZG35	29	38	54	26	2	7	8	9.6	85	87	3.9	2.00
28.	KZG36	31	43	58	36	1	3	9	8.3	90	28	0.9	1.74
29.	KZG37	32	43	58	24	2	9	10	9.8	93	80	0.9	1.87
30.	KZG39	31	42	57	12	1	4	7	8.3	93	49	0.9	1.96
31.	KZG40	31	41	56	28	3	11	12	10.6	94	134	3.4	2.12
32.	KZG41	32	44	58	45	2	9	9	9.8	94	98	1.9	2.00
33.	KZG42	30	43	57	22	6	18	13	11.5	93	260	3.9	2.05
34.	KZG43	29	39	55	30	2	8	11	9.7	88	93	1.4	1.76
35.	KZG44	27	36	52	22	2	8	10	9.9	84	94	3.4	2.10
36.	KZG47	28	37	54	38	3	13	12	11.2	87	154	1.4	1.56
37.	KZG48	29	39	54	30	2	6	9	9.1	86	65	0.9	1.87
38.	KZG50	28	38	52	28	1	4	10	8.2	87	42	2.4	1.95
39.	KZG51	30	41	56	35	3	11	11	10.9	89	120	2.4	1.87
40.	KZG52	31	43	58	28	2	6	12	9.4	93	64	0.4	1.68
41.	KZG53	29	38	53	21	3	13	11	11.6	89	151	2.4	1.99
42.	KZG54	27	37	52	43	2	5	10	8.7	88	61	0.4	1.66
43.	KZG55	30	42	57	26	2	9	9	10.1	88	90	0.9	1.85
44.	KZG57	28	38	53	45	4	16	11	11.7	88	227	3.0	1.75
45.	KZG58	27	36	52	20	3	11	12	10.8	88	121	1.9	2.10
46.	KZG60	28	37	53	41	1	4	10	8.5	87	36	0.9	2.05
47.	KZG61	29	37	53	30	6	17	9	11.2	86	217	3.4	1.94
48.	KZG62	27	36	52	30	2	8	11	9.9	86	70	1.4	1.99
49.	KZG65	29	37	52	33	4	11	12	10.5	87	125	2.9	1.98
50.	KZG66	28	37	53	41	3	10	11	10.2	88	107	0.4	2.00
51.	KZG67	27	36	52	34	3	12	13	11.6	87	131	1.4	2.08
52.	KZG68	31	42	57	37	5	17	12	10.8	91	220	1.9	1.86
53.	KZG71	28	38	53	28	5	15	10	9.9	88	178	1.4	1.93
54.	KZG73	29	38	53	30	4	9	11	9.4	87	76	2.4	2.00
55.	KZG74	28	36	52	36	6	19	13	11.8	86	267	2.0	2.06
56.	KZG75	29	38	54	32	4	9	11	10.6	90	71	1.5	2.02

57.	KZG76	30	42	57	29	5	11	12	10.2	92	110	1.5	1.85
58.	KZG77	27	36	51	34	3	3	12	8.4	85	26	1.0	1.78
59.	KZG78	31	43	58	32	2	12	11	8.8	93	124	0.5	1.72
60.	KZG79	29	37	52	31	4	11	13	9.8	86	115	2.0	1.88
61.	KZG80	31	43	58	25	3	12	10	9.6	94	127	1.0	1.97
62.	KZG82	29	38	53	38	5	11	9	10.4	88	115	1.5	2.00
63.	KZG84	29	38	53	32	6	15	13	11.9	87	175	0.5	2.11
64.	KZG85	30	41	57	38	2	10	11	9.4	91	88	2.5	2.00
65.	KZG88	29	38	52	50	3	13	12	11.7	87	145	1.0	1.89
66.	KZG89	29	37	52	44	5	10	12	11.9	87	100	2.5	2.00
67.	KZG90	28	37	51	30	4	7	9	11.3	87	51	1.5	1.85
68.	KZG92	28	38	52	47	6	19	13	10.8	87	265	4.0	2.10
69.	KZG93	30	42	56	53	1	11	12	9.6	91	105	1.5	2.00
70.	KZG94	29	40	55	32	3	8	11	9.9	91	71	1.0	1.85
71.	KZG95	29	37	52	36	3	10	12	8.5	88	96	0.5	1.78
72.	KZG96	29	38	53	37	4	16	14	10.8	89	201	1.0	1.68
73.	KZG98	29	39	54	38	5	16	12	11.6	90	195	0.5	1.94
74.	KZG99	31	42	57	34	4	11	9	11.6	93	112	0.5	1.93
75.	KZG100	31	42	56	12	5	11	8	10.1	91	110	1.0	2.00
76.	KZG103	29	40	54	27	3	13	12	11.3	89	141	0.5	2.10
77.	KZG104	31	39	48	34	3	11	11	10.8	87	107	1.0	1.85
78.	KZG105	26	36	51	34	2	7	10	10.4	86	59	0.5	1.75
79.	KZG106	27	36	51	46	2	8	9	11.6	86	75	0.5	1.78
80.	KZG107	32	44	58	64	3	7	11	10.5	94	52	1.0	2.10
81.	KZG108	27	36	51	32	6	19	13	8.2	86	295	3.0	2.00
82.	KZG109	30	41	56	42	4	8	12	9.4	92	70	0.5	1.87
83.	KZG110	29	38	52	34	4	12	11	8.3	87	128	1.0	1.99
84.	KZG112	31	43	58	41	2	7	9	10.4	94	60	1.5	2.05
85.	KZG113	29	37	52	38	5	13	12	9.6	87	140	1.0	2.08
86.	KZG114	27	37	52	33	5	17	14	10.8	88	225	1.0	1.97
87.	KZG115	28	39	54	22	6	21	12	8.4	90	347	5.0	2.10
88.	KZG116	30	42	56	47	2	12	10	8.7	92	108	1.5	1.99
89.	KZG117	31	42	57	34	2	12	9	9.4	92	112	0.5	1.75
90.	KZG118	27	36	51	17	5	17	8	8.9	86	226	2.5	2.00
91.	KZG120	31	43	58	37	5	15	13	11.3	93	153	1.5	1.87
92.	KZG122	31	43	58	43	4	7	9	9.5	94	62	1.0	2.10
93.	KZG123	30	41	56	29	5	16	12	11.7	91	165	2.0	2.00
94.	KZG124	27	36	51	38	3	12	13	10.5	86	112	3.0	1.83
95.	KZG125	29	40	54	29	4	6	11	9.8	89	41	2.0	1.75
96.	KZG126	31	43	58	55	5	14	12	10.4	93	143	3.0	1.68
97.	KZG127	31	42	57	35	4	12	13	9.6	93	112	2.0	1.85
98.	KZG128	30	41	55	48	5	13	10	9.9	91	175	2.0	2.00
99.	KZG129	31	43	57	38	3	10	11	11.6	92	92	0.5	1.80
100.	KZG130	30	42	51	46	4	15	13	11.0	92	185	1.0	1.90
101.	KZG131	31	43	58	32	2	8	9	11.3	94	76	1.0	2.00
102.	KZG132	30	42	55	37	2	9	11	11.2	91	87	1.5	2.00
103.	KZG133	30	42	56	45	1	6	12	10.6	91	45	1.0	1.95
104.	KZG134	30	43	57	42	3	11	13	11.8	92	107	2.5	2.10
105.	KZG135	31	43	58	14	3	12	14	9.4	93	117	1.5	1.95
106.	KZG136	29	40	55	37	2	7	11	10.5	90	63	1.0	1.75
107.	KZG137	31	43	58	30	5	17	10	11.2	94	227	3.5	2.05
108.	KZG138	31	43	58	30	2	7	9	10.3	94	63	1.0	1.83
109.	KZG139	30	42	56	43	2	8	11	9.3	91	77	1.0	1.75
110.	KZG141	27	37	52	30	4	15	11	10.8	87	153	2.5	1.80
111.	KZG142	31	43	58	30	3	10	13	10.7	94	97	2.0	2.00
112.	KZG143	31	44	59	20	5	17	11	9.4	94	193	1.0	1.85
113.	KZG144	27	38	53	39	1	9	10	10.6	88	83	2.5	1.90
114.	KZG145	27	37	52	39	2	7	11	8.5	88	61	1.5	2.00
115.	KZG146	28	39	54	37	4	12	8	11.6	90	112	2.0	2.05
116.	KZG147	28	38	53	38	2	7	12	10.9	87	59	0.5	1.85
117.	KZG148	32	44	59	47	3	13	11	11.3	94	127	2.5	1.90
118.	KZG149	29	39	53	30	2	7	12	10.2	89	61	1.0	1.65
119.	KZG150	31	43	58	30	4	19	13	11.5	93	207	2.5	1.80
120.	KZG151	28	38	53	50	2	9	11	10.4	87	81	1.0	2.10
121.	KZG152	31	44	59	43	3	16	10	8.7	94	177	3.5	1.85
122.	KZG153	29	40	55	37	4	18	12	10.6	91	205	3.5	1.95
123.	KZG154	29	39	54	35	2	9	11	10.9	88	84	1.5	1.95
124.	KZG155	26	36	51	44	3	13	9	11.1	87	127	4.0	1.75

125.	KZG156	27	36	51	38	3	13	13	11.3	86	137	2.0	2.05
126.	KZG157	28	38	53	45	4	16	11	11.7	88	227	3.0	1.75
127.	KZG160	30	42	57	16	1	3	12	10.4	92	17	1.5	2.00
128.	KZG161	32	44	59	41	3	12	12	11.8	94	109	3.0	1.87
129.	KZG162	29	40	54	40	2	9	9	10.3	91	73	1.0	1.99
130.	KZG163	29	41	55	37	3	13	14	11.9	91	128	2.0	1.78
131.	KZG164	26	36	51	36	2	7	11	10.8	86	68	1.5	2.10
132.	KZG166	32	44	59	29	2	11	10	10.2	94	97	1.0	1.75
133.	KZG167	28	39	54	17	1	3	8	9.1	90	25	0.5	1.85
134.	KZG168	29	39	54	32	3	12	12	11.8	89	104	1.0	2.00
135.	KZG169	29	40	56	30	3	11	9	11.0	92	142	2.0	1.85
136.	KZG170	28	39	54	30	2	9	11	8.3	88	76	1.5	1.90
137.	KZG171	30	42	56	35	3	14	10	10.6	91	137	2.5	1.85
138.	KZG172	29	40	55	44	3	13	12	8.9	90	136	4.0	1.85
139.	KZG173	32	44	59	15	2	8	12	11.8	94	65	0.5	2.00
140.	KZG174	29	41	57	37	3	13	13	10.7	91	117	2.0	1.65
141.	KZG175	29	40	55	33	2	6	10	10.4	89	53	1.0	1.85
142.	KZG176	26	36	51	34	3	12	8	10.0	86	147	1.0	2.00
143.	KZG177	28	39	53	43	1	5	11	11.4	87	45	1.0	1.80
144.	KZG178	29	40	56	40	3	14	12	10.7	90	142	1.5	1.90
145.	KZG179	29	40	55	20	2	9	14	9.8	90	62	1.5	1.95
146.	KZG180	27	37	52	21	3	13	12	8.8	86	117	1.0	1.80
147.	KZG181	32	44	59	33	4	12	9	9.1	94	153	1.0	2.00
148.	KZG182	29	40	56	49	2	10	10	9.3	90	73	1.5	1.95
149.	KZG183	29	41	56	34	2	10	11	10.8	91	82	1.5	1.85
150.	KZG184	27	37	52	24	3	11	11	10.9	87	103	1.0	2.00
151.	KZG185	30	42	57	33	2	11	12	11.5	91	97	2.0	1.85
152.	KZG186	28	39	53	24	3	12	8	10.6	89	109	1.0	1.90
153.	KZG187	29	40	56	45	1	4	15	9.3	90	32	0.5	1.85
154.	KZG188	31	43	58	22	2	5	11	11.6	93	58	0.5	1.85
155.	KZG189	32	44	59	26	3	13	10	8.2	94	147	1.0	2.00
156.	KZG190	32	43	57	54	2	7	10	10.2	91	68	0.5	1.65
157.	KZG191	27	37	52	37	4	14	12	10.9	88	156	2.0	1.85
158.	KZG192	28	38	53	28	1	5	12	11.1	88	53	0.5	2.00
159.	KZG193	29	40	55	41	1	6	11	11.6	91	57	0.5	1.90
160.	KZG194	29	39	54	39	2	11	13	10.4	91	96	1.0	1.85
161.	KZG195	26	36	51	46	2	7	13	8.7	87	83	1.0	1.90
162.	KZG196	30	42	57	41	2	10	11	9.3	93	91	1.0	1.85
163.	KZG197	31	43	58	48	2	11	14	11.4	94	102	1.5	1.85
164.	KZG198	32	44	59	39	3	13	14	10.9	94	126	1.5	2.00
165.	KZG199	29	41	56	42	2	12	11	11.2	89	117	2.0	1.65
166.	KZG200	29	40	55	35	5	18	12	11.1	89	212	1.0	1.90
167.	KZG201	29	39	54	49	4	13	11	10.8	91	146	2.5	1.85
168.	KZG202	28	39	53	23	3	9	10	9.6	89	107	1.5	1.85
169.	KZG203	29	41	56	43	2	8	12	11.7	90	88	1.0	2.00
170.	KZG204	30	42	57	37	3	10	11	9.4	92	104	2.0	1.65
171.	KZG206	31	43	58	42	1	5	13	10.8	94	42	0.5	2.00
172.	KZG207	26	36	51	27	4	12	9	11.1	87	133	2.0	1.90
173.	KZG208	42	44	59	44	2	6	10	11.6	94	65	1.0	1.85
174.	KZG209	39	42	58	40	4	12	12	11.9	93	132	1.5	1.90
175.	KZG210	29	40	56	25	2	6	11	9.8	90	72	1.0	1.85
176.	KZG211	27	37	52	28	4	13	10	10.3	87	133	1.0	1.85
177.	KZG212	31	43	58	60	2	9	10	10.9	93	93	1.0	2.00
178.	KZG213	26	36	52	30	2	10	11	8.6	88	98	1.5	1.65
179.	KZG214	30	42	57	53	3	10	13	10.5	91	113	1.5	1.85
180.	KZG215	30	41	56	45	3	13	8	10.3	92	137	1.5	2.00
181.	KZG216	32	44	59	30	2	8	10	11.1	94	87	1.0	1.90
182.	KZG217	27	37	52	38	2	9	9	10.4	89	96	2.0	1.85
183.	KZG218	32	44	59	32	5	19	9	10.7	94	207	2.5	1.90
184.	KZG219	28	38	53	39	2	7	11	9.5	89	78	2.0	1.85
185.	KZG221	29	39	54	30	2	12	12	10.3	90	109	2.0	2.00
186.	KZG222	29	40	54	43	3	11	13	11.6	89	124	2.0	1.65
187.	KZG223	31	43	59	20	3	14	10	11.2	94	139	1.0	1.85
188.	KZG224	26	36	52	41	2	9	11	10.9	87	88	2.0	1.92
189.	KZG226	32	44	59	22	3	15	8	9.8	94	133	1.5	1.88
190.	KZG227	29	40	55	32	2	9	9	9.2	91	79	1.5	1.95
191.	KZG228	31	42	56	33	4	16	11	10.1	90	154	2.0	1.80
192.	KZG229	27	37	53	29	2	8	12	9.4	87	82	1.0	1.85

193.	KZG230	32	44	59	40	4	19	14	11.2	93	195	3.0	1.90
194.	KZG231	26	36	52	45	2	10	13	8.7	86	113	3.0	1.85
195.	KZG232	27	36	51	29	2	5	13	11.3	86	46	0.5	1.80
196.	KZG233	30	41	57	33	2	10	12	11.6	93	104	2.0	1.90
197.	KZG234	42	44	55	35	3	12	10	10.8	91	117	1.0	1.98
198.	KZG236	29	40	54	25	2	9	9	11.4	90	97	1.5	1.90
199.	KZG237	27	37	58	49	2	9	11	8.9	93	88	2.0	1.85
200.	KZG238	41	48	56	42	2	9	9	9.1	90	84	1.5	1.85
201.	KZG239	36	41	51	30	3	15	11	9.8	86	148	2.0	2.00
202.	KZG240	29	41	56	43	2	6	10	10.9	90	59	1.0	1.65
203.	KZG241	32	44	58	28	4	17	13	10.6	93	159	1.0	1.85
204.	KZG242	28	40	56	33	4	19	11	10.7	91	181	0.5	1.90
205.	KZG243	26	36	51	43	2	9	12	11.4	87	94	0.5	1.85
206.	KZG245	26	36	52	49	3	12	12	9.7	88	117	3.0	2.00
207.	KZG246	31	42	56	48	4	20	12	11.5	90	198	2.0	1.87
208.	KZG247	29	40	55	38	2	10	9	11.7	90	96	1.5	1.90
209.	KZG249	26	37	53	44	3	9	14	9.3	89	105	1.5	1.95
210.	KZG250	29	39	54	39	2	9	11	11.4	90	93	1.0	1.80
211.	KZG251	26	37	52	36	1	2	11	9.8	89	21	0.5	1.90
212.	KZG252	32	44	59	40	3	12	13	8.8	94	126	0.5	1.87
213.	KZG253	31	43	59	29	5	21	13	11.1	93	207	2.0	1.85
214.	KZG254	27	38	54	19	1	6	12	11.7	88	63	2.0	1.90
215.	KZG255	32	44	59	30	2	9	10	9.6	94	86	1.0	1.65
216.	KZG256	29	40	54	28	2	8	9	10.3	89	69	1.0	1.85
217.	KZG257	26	37	51	23	1	4	10	10.1	86	38	0.5	1.92
218.	KZG258	26	36	52	33	3	16	9	10.9	86	147	1.0	1.85
219.	KZG259	27	38	53	29	1	2	11	8.3	88	22	0.5	1.87
220.	KZG260	27	37	52	38	1	3	12	11.3	87	28	1.0	1.96
221.	KZG262	29	39	55	46	2	11	12	11.0	91	103	1.5	1.85
222.	KZG263	31	42	58	45	2	9	12	11.9	93	84	1.0	2.00
223.	KZG264	29	41	56	51	2	10	13	9.1	92	96	1.0	1.95
224.	KZG265	29	40	55	28	3	12	14	8.4	90	108	1.0	1.85
225.	KZG266	26	37	53	28	3	11	14	10.3	89	106	1.5	1.90
226.	KZG267	28	39	54	36	4	16	11	10.5	90	165	2.0	1.85
227.	KZG268	29	40	56	57	1	4	11	11.6	91	37	0.5	1.87
228.	KZG269	26	36	52	27	1	4	10	9.2	87	44	0.5	1.95
229.	KZG270	26	37	52	37	5	21	9	11.7	88	207	2.5	1.65
230.	KZG272	29	39	54	24	1	7	8	11.7	90	58	1.0	1.90
231.	KZG273	27	38	52	35	2	9	8	8.7	87	81	1.0	1.85
232.	KZG277	27	36	51	25	1	6	10	11.4	86	66	1.5	1.85
233.	KZG278	26	37	53	35	3	13	12	10.5	89	126	0.5	2.00
234.	KZG279	30	42	58	46	3	17	12	9.1	94	163	1.5	1.90
235.	KZG280	29	41	57	42	3	16	13	9.4	91	153	2.0	1.85
236.	KZG282	28	39	54	38	2	9	11	9.1	90	85	0.5	1.85
237.	KZG283	27	38	52	40	1	2	10	11.7	88	19	1.0	1.95
238.	KZG284	26	36	51	44	2	6	14	10.9	86	54	0.5	2.05
239.	KZG285	26	36	52	24	2	9	11	10.0	87	93	1.0	1.85
240.	KZG287	27	38	54	42	3	14	11	11.8	90	137	3.0	1.92
241.	KZG288	26	36	52	37	2	12	11	10.4	88	108	1.0	1.89
242.	KZG289	26	37	53	67	3	15	13	9.6	88	136	2.0	1.85
243.	KZG290	27	37	52	25	2	10	12	11.2	87	93	2.0	2.10
244.	KZG291	26	36	51	38	2	9	11	8.3	87	88	2.0	1.75
245.	KZG292	29	39	53	36	2	10	13	10.7	90	96	2.5	1.88
246.	KZG293	29	41	55	47	2	8	14	9.4	91	74	2.0	2.00
247.	KZG294	32	44	59	24	4	18	9	11.3	94	176	2.0	1.97
248.	KZG296	27	39	55	27	1	5	8	11.6	89	43	1.0	1.95
249.	KZG297	28	40	56	30	1	6	11	11.9	90	53	0.5	1.85
250.	KZG298	31	42	56	42	2	10	12	10.6	92	93	2.5	1.88
251.	KZG299	29	40	54	25	3	11	12	9.2	90	106	2.5	1.90
252.	KZG300	26	36	52	44	3	13	13	11.4	88	137	2.5	1.85

**b. Data base of 252 landraces for seed characterization****Table- Seed Characterization of Kala zeera accessions using Image-J Software**

S. No.	Accession Code	Area (mm)	Perimeter (mm)	Feret (mm)	Average Radius (mm)
1.	KZG1	9014.53	189.69	78.08	0.725
2.	KZG2	9046.28	194.49	83.25	0.657
3.	KZG3	6282.73	162.7	67.96	0.565
4.	KZG4	8904.93	204.83	90.78	0.801
5.	KZG6	5386.56	161.89	71.96	0.695
6.	KZG8	7594.71	182.45	78.78	0.664
7.	KZG9	5185.24	146.68	62.08	0.606
8.	KZG10	4851.51	150.73	65.85	0.791
9.	KZG11	6894.09	176.17	76.9	0.712
10.	KZG12	10102.61	208.3	90.31	0.667
11.	KZG13	10161.76	209.06	89.13	0.648
12.	KZG14	4995.56	147.95	63.73	0.665
13.	KZG15	8470.42	194.82	85.37	0.726
14.	KZG16	6758.28	162.88	66.57	0.541
15.	KZG17	9343.78	191.99	79.49	0.545
16.	KZG19	11679.76	202.72	80.66	0.501
17.	KZG20	13278.32	246.01	107	0.786
18.	KZG23	10908.35	206.58	86.31	0.56
19.	KZG24	7308.14	169.37	70.08	0.556
20.	KZG25	6594.35	159.25	66.32	0.573
21.	KZG26	10564.98	210.79	90.78	0.645
22.	KZG27	10568.04	212.45	91.48	0.644
23.	KZG30	9786.52	199.19	83.02	0.562
24.	KZG32	6946.9	166.9	68.9	0.559
25.	KZG33	7585.54	174.58	72.2	0.549
26.	KZG34	11839.81	216.75	90.78	0.805
27.	KZG35	3678.53	134.22	59.5	0.569
28.	KZG36	3579.75	119.53	49.62	0.545
29.	KZG37	3805.76	126.64	53.62	0.609
30.	KZG39	3419.71	123.43	53.15	0.68
31.	KZG40	4349.04	142.03	63.02	0.749
32.	KZG41	4521.2	140.45	60.2	0.649
33.	KZG42	2755.07	103.68	42.56	0.532
34.	KZG43	2861.61	112.88	48.68	0.666
35.	KZG44	2886.75	103.59	42.8	0.55
36.	KZG47	4371.73	131.58	54.32	0.54
37.	KZG48	4363.74	136.44	58.09	0.62
38.	KZG50	2462.27	104.91	45.62	0.676
39.	KZG51	3821.17	125.8	53.15	0.608

40.	KZG52	2814.1	111.82	48.44	0.673
41.	KZG53	2749.55	111.24	48.21	0.694
42.	KZG54	3654.07	119.96	48.91	0.52
43.	KZG55	2804.11	107.46	44.92	0.572
44.	KZG57	4168.3	133.57	57.15	0.634
45.	KZG58	2706.86	105.06	43.74	0.572
46.	KZG60	4920.3	148.18	64.2	0.669
47.	KZG61	3042.59	110.62	46.09	0.563
48.	KZG62	2630.89	107.93	46.8	0.673
49.	KZG65	4175.47	133.37	56.91	0.612
50.	KZG66	3510.37	118.36	48.68	0.536
51.	KZG67	3027.67	113.44	48.44	0.625
52.	KZG68	3775.66	123.65	51.5	0.569
53.	KZG71	3426.41	119.03	50.09	0.583
54.	KZG73	3718.86	135.4	60.44	0.795
55.	KZG74	3619.26	125.82	54.09	0.653
56.	KZG75	4060.23	127.72	52.91	0.555
57.	KZG76	3901.83	125.95	52.68	0.566
58.	KZG77	4896.2	147.79	64.2	0.667
59.	KZG78	5079.41	148.8	63.73	0.651
60.	KZG79	3604.44	122.76	51.97	0.612
61.	KZG80	4234.97	140.7	61.85	0.735
62.	KZG82	3323.98	121.96	52.91	0.679
63.	KZG84	3488.97	126.83	55.73	0.714
64.	KZG85	3502.73	134.67	60.91	0.842
65.	KZG88	3689.35	131.32	57.85	0.729
66.	KZG89	3920.06	126.86	52.91	0.574
67.	KZG90	2641.71	110.41	48.21	0.72
68.	KZG92	3502.96	126.64	55.5	0.704
69.	KZG93	5221.58	154.16	67.49	0.701
70.	KZG94	2943.34	109.67	46.09	0.571
71.	KZG95	5182.65	149.39	63.97	0.628
72.	KZG96	3176.99	111.69	46.09	0.529
73.	KZG98	4393.84	138.88	60.2	0.675
74.	KZG99	3055.52	114.26	48.91	0.629
75.	KZG100	3314.93	117.12	49.38	0.589
76.	KZG103	4174	133.12	57	0.621
77.	KZG104	3815.87	127.91	54.79	0.629
78.	KZG105	4849.87	143.27	60.91	0.613
79.	KZG106	3400.16	122.41	52.53	0.644
80.	KZG107	5247.68	148.89	63.26	0.604
81.	KZG108	3719.68	128.89	55.97	0.678
82.	KZG109	4804.83	149.08	65.61	0.724
83.	KZG110	2821.63	106.28	43.97	0.55
84.	KZG112	4143.02	137.66	60.44	0.72

85.	KZG113	3609.5	126.96	55.26	0.671
86.	KZG114	2936.75	108.83	45.62	0.574
87.	KZG115	4554	146.11	64.44	0.725
88.	KZG116	2961.92	112.16	47.74	0.616
89.	KZG117	2288.11	96.07	39.98	0.556
90.	KZG118	3415.82	124.51	54.32	0.693
91.	KZG120	3088.56	117.64	51.03	0.668
92.	KZG122	3678.76	124.21	52.68	0.598
93.	KZG123	3009.66	113.38	48.21	0.617
94.	KZG124	2979.56	105.57	41.86	0.476
95.	KZG125	2669.46	103.16	42.56	0.548
96.	KZG126	2752.13	108.2	45.62	0.652
97.	KZG127	3170.06	110.5	44.68	0.502
98.	KZG128	5337.52	147.1	61.61	0.584
99.	KZG129	3650.77	121.31	50.56	0.564
100.	KZG130	3780.48	125.38	52.91	0.603
101.	KZG131	2592.09	98.36	38.8	0.472
102.	KZG132	2541.17	99.49	40.68	0.532
103.	KZG133	3031.3	112.28	47.5	0.6
104.	KZG134	4595.4	140.46	59.97	0.625
105.	KZG135	4744.23	137.49	57.15	0.548
106.	KZG136	2709.56	102.36	41.62	0.514
107.	KZG137	3755.08	119.32	47.97	0.485
108.	KZG138	3126.19	109.83	44.68	0.509
109.	KZG139	3592.21	122.45	51.97	0.616
110.	KZG141	2959.68	116.45	50.8	0.692
111.	KZG142	3313.99	119.51	51.03	0.643
112.	KZG143	2812.81	104.86	42.8	0.527
113.	KZG144	2847.62	103.67	42.09	0.503
114.	KZG145	3141.83	112.46	46.56	0.547
115.	KZG146	3772.01	124.13	51.97	0.572
116.	KZG147	2702.98	101.87	41.39	0.51
117.	KZG148	4475.8	139.23	59.97	0.647
118.	KZG149	2753.31	104.18	43.03	0.535
119.	KZG150	3014.72	109.16	44.92	0.542
120.	KZG151	4334.69	133.93	56.2	0.587
121.	KZG152	3187.46	114.91	48.44	0.594
122.	KZG153	3223.09	118.9	51.27	0.649
123.	KZG154	4020.72	131.62	56.44	0.624
124.	KZG155	4537.66	136.55	57.38	0.587
125.	KZG156	2814.1	111.14	47.97	0.65
126.	KZG157	2926.05	115.75	50.56	0.704
127.	KZG160	1841.26	85.84	35.74	0.564
128.	KZG161	2878.07	104.19	41.86	0.485
129.	KZG162	2961.21	114.27	49.38	0.651

130.	KZG163	3002.02	105.89	42.09	0.472
131.	KZG164	3381.13	117.25	49.15	0.572
132.	KZG166	3030	109.57	45.39	0.545
133.	KZG167	3411	123.15	53.38	0.695
134.	KZG168	2661.59	107.03	45.86	0.63
135.	KZG169	2221.44	89.72	35.04	0.443
136.	KZG170	3869.97	126.34	53.15	0.599
137.	KZG171	3197.69	112.1	46.09	0.538
138.	KZG172	3293.65	117.45	49.62	0.614
139.	KZG173	2464.38	101.67	43.27	0.602
140.	KZG174	2771.65	114.8	50.8	0.75
141.	KZG175	3439.81	112.91	44.68	0.462
142.	KZG176	2908.18	111.53	47.5	0.625
143.	KZG177	5398.55	153.52	66.08	0.686
144.	KZG178	2092.32	98.07	43.03	0.726
145.	KZG179	3032.47	107.04	43.27	0.503
146.	KZG180	2048.22	96.81	42.56	0.708
147.	KZG181	2427.58	98.78	40.92	0.562
148.	KZG182	3420.41	113.34	45.62	0.495
149.	KZG183	2747.55	100.33	39.04	0.451
150.	KZG184	2675.81	99.24	39.04	0.452
151.	KZG185	3700.99	122.07	50.8	0.566
152.	KZG186	3099.38	115.55	49.38	0.643
153.	KZG187	4043.89	136.13	59.73	0.716
154.	KZG188	2711.56	104.61	43.74	0.569
155.	KZG189	2822.22	104.14	43.03	0.535
156.	KZG190	3415.12	116.59	48.44	0.551
157.	KZG191	3245.55	112.41	45.86	0.531
158.	KZG192	2773.89	106.04	43.97	0.562
159.	KZG193	4092.33	131.84	56.2	0.627
160.	KZG194	2504.83	100.82	42.09	0.567
161.	KZG195	4990.15	148.9	64.67	0.668
162.	KZG196	2984.02	108.99	45.39	0.555
163.	KZG197	2994.65	115.31	50.09	0.673
164.	KZG198	3855.03	122.51	50.09	0.518
165.	KZG199	5034.96	145.02	61.14	0.599
166.	KZG200	3659.48	119.71	49.15	0.537
167.	KZG201	4030.95	126.92	52.91	0.553
168.	KZG202	3532.24	121.47	51.27	0.599
169.	KZG203	3820.81	127.05	53.85	0.601
170.	KZG204	3027.65	110.77	46.56	0.567
171.	KZG206	3079.16	118.3	51.5	0.695
172.	KZG207	3007.19	112.12	47.74	0.609
173.	KZG208	3056.46	111.39	46.33	0.557
174.	KZG209	3361.14	115.22	47.5	0.541



175.	KZG210	2878.9	110.74	47.27	0.623
176.	KZG211	2549.4	105.53	45.62	0.675
177.	KZG212	2455.45	101.15	42.8	0.594
178.	KZG213	3367.73	113.88	46.56	0.535
179.	KZG214	2601.85	102.03	42.33	0.546
180.	KZG215	3823.05	122.19	50.09	0.526
181.	KZG216	3216.98	115.68	48.91	0.593
182.	KZG217	3705.81	117.57	46.33	0.465
183.	KZG218	3180.17	108.87	43.03	0.47
184.	KZG219	3812.35	125.8	53.38	0.608
185.	KZG221	4054.47	124.46	50.56	0.501
186.	KZG222	3919.71	131.28	56.44	0.661
187.	KZG223	2703.8	98.16	37.86	0.43
188.	KZG224	2640.42	103.42	43.27	0.567
189.	KZG226	3308.35	114.97	47.74	0.548
190.	KZG227	3661.71	119.12	48.44	0.523
191.	KZG228	3848.33	128.99	55.26	0.63
192.	KZG229	2179.34	94.92	39.98	0.589
193.	KZG230	3158.53	116.05	49.38	0.614
194.	KZG231	3165.94	114.94	48.68	0.595
195.	KZG232	2613.14	105.2	44.68	0.612
196.	KZG233	3331.16	122.48	53.15	0.692
197.	KZG234	2820.22	113.57	49.62	0.725
198.	KZG236	3064.58	115.18	49.38	0.641
199.	KZG237	3752.61	124.68	52.91	0.608
200.	KZG238	3567.87	117.19	47.97	0.519
201.	KZG239	3317.75	113.35	46.09	0.519
202.	KZG240	3327.4	116.39	48.68	0.563
203.	KZG241	2807.52	106.39	44.21	0.561
204.	KZG242	3226.85	112.13	46.09	0.535
205.	KZG243	3921.83	122.57	49.38	0.504
206.	KZG245	4029.31	134.01	58.32	0.681
207.	KZG246	3397.6	119.15	50.09	0.597
208.	KZG247	3670.18	129.14	56.2	0.693
209.	KZG249	2926.29	121.55	54.56	0.808
210.	KZG250	3399.13	120.26	51.27	0.618
211.	KZG251	3614.67	118.95	48.44	0.545
212.	KZG252	1989.31	86.3	34.1	0.465
213.	KZG253	3292.23	114.26	47.27	0.552
214.	KZG254	5004.03	143.34	60.2	0.577
215.	KZG255	2851.26	105.38	42.8	0.512
216.	KZG256	3480.85	118.55	49.38	0.553
217.	KZG257	3625.96	133.79	59.73	0.723
218.	KZG258	3337.16	112.56	45.39	0.488
219.	KZG259	3399.24	120.91	51.97	0.633

220.	KZG260	3406.3	117.13	48.91	0.567
221.	KZG262	3701.69	119.75	48.91	0.513
222.	KZG263	3915.24	123.76	50.8	0.529
223.	KZG264	4201.11	132.11	55.73	0.591
224.	KZG265	2858.44	111.95	48.21	0.656
225.	KZG266	3421.7	123.93	53.85	0.682
226.	KZG267	3845.27	138.72	62.08	0.802
227.	KZG268	3773.31	124.17	52.21	0.575
228.	KZG269	4879.15	143.42	61.14	0.632
229.	KZG270	3330.45	116.94	49.15	0.576
230.	KZG272	3750.26	122.64	50.8	0.551
231.	KZG273	3025.3	118.26	51.74	0.722
232.	KZG277	3954.28	125.72	52.44	0.552
233.	KZG278	4321.41	132.89	55.5	0.57
234.	KZG279	3091.86	114.33	48.44	0.6
235.	KZG280	3170.06	111.79	46.09	0.545
236.	KZG282	3946.17	125.65	52.21	0.545
237.	KZG283	3424.17	122.26	52.44	0.645
238.	KZG284	3843.27	131.23	57.15	0.673
239.	KZG285	3751.43	121.51	49.85	0.524
240.	KZG287	4971.93	141.38	58.56	0.555
241.	KZG288	3668.3	116.29	46.09	0.463
242.	KZG289	4617.39	135.87	56.91	0.566
243.	KZG290	3527.54	114.37	45.15	0.458
244.	KZG291	3242.02	110.62	44.45	0.488
245.	KZG292	3590.92	123.41	52.21	0.629
246.	KZG293	4196.05	128.62	53.15	0.552
247.	KZG294	4025.66	127.32	53.15	0.559
248.	KZG296	3032.94	117.59	51.27	0.701
249.	KZG297	3689.93	122.45	51.27	0.56
250.	KZG298	3749.43	119.47	48.44	0.495
251.	KZG299	3809.76	118.36	46.56	0.451
252.	KZG300	4342.45	129.14	52.44	0.514

**c. Data base of 252 landraces for nutritional characterization**

**Table- Estimation of total protein content using spectrophotometer method**

S. No.	Kala zeera genotype name	Spectrophotometer reading	Protein content mg/ml
1.	KZG1	1.513	3.7825
2.	KZG2	1.654	4.1350
3.	KZG3	1.773	4.4325
4.	KZG4	1.856	4.6400
5.	KZG6	1.306	3.2650
6.	KZG8	1.469	3.6725
7.	KZG9	1.733	4.3325
8.	KZG10	1.682	4.2050
9.	KZG11	1.466	3.6650
10.	KZG12	1.344	3.3600
11.	KZG13	1.347	3.3675
12.	KZG14	0.800	2.0000
13.	KZG15	1.632	4.0800
14.	KZG16	1.637	4.0925
15.	KZG17	0.984	2.4600
16.	KZG19	1.396	3.4900
17.	KZG20	1.506	3.7650
18.	KZG23	1.554	3.8850
19.	KZG24	1.239	3.0975
20.	KZG25	1.212	3.0300
21.	KZG26	1.641	4.1025

22.	KZG27	1.419	3.5475
23.	KZG30	1.733	4.3325
24.	KZG32	1.137	2.8425
25.	KZG33	0.800	2.0000
26.	KZG34	1.487	3.7175
27.	KZG35	1.094	2.7350
28.	KZG36	1.677	4.1925
29.	KZG37	0.869	2.1725
30.	KZG39	1.321	3.3025
31.	KZG40	1.114	2.7850
32.	KZG41	1.043	2.6075
33.	KZG42	0.796	1.9900
34.	KZG43	0.846	2.1150
35.	KZG44	1.145	2.8625
36.	KZG47	0.731	1.8275
37.	KZG48	0.961	2.4025
38.	KZG50	1.042	2.6050
39.	KZG51	0.960	2.4000
40.	KZG52	1.108	2.7700
41.	KZG53	0.881	2.2025
42.	KZG54	1.003	2.5075
43.	KZG55	0.761	1.9025
44.	KZG57	1.179	2.9475
45.	KZG58	0.994	2.4850
46.	KZG60	0.846	2.1150
47.	KZG61	0.913	2.2825

48.	KZG62	0.902	2.2550
49.	KZG65	0.842	2.1050
50.	KZG66	0.925	2.3125
51.	KZG67	0.822	2.0550
52.	KZG68	0.908	2.2700
53.	KZG71	1.015	2.5375
54.	KZG73	0.880	2.2000
55.	KZG74	0.831	2.0775
56.	KZG75	1.031	2.5775
57.	KZG76	0.816	2.0400
58.	KZG77	0.945	2.3625
59.	KZG78	1.028	2.5700
60.	KZG79	1.141	2.8525
61.	KZG80	1.011	2.5275
62.	KZG82	0.926	2.3150
63.	KZG84	0.916	2.2900
64.	KZG85	1.037	2.5925
65.	KZG88	1.109	2.7725
66.	KZG89	1.038	2.5950
67.	KZG90	0.724	1.8100
68.	KZG92	0.826	2.0650
69.	KZG93	1.097	2.7425
70.	KZG94	0.881	2.2025
71.	KZG95	1.075	2.6875
72.	KZG96	0.963	2.4075
73.	KZG98	0.828	2.0700

74.	KZG99	1.188	2.9700
75.	KZG100	1.080	2.7000
76.	KZG103	1.213	3.0325
77.	KZG104	0.942	2.3550
78.	KZG105	0.948	2.3700
79.	KZG106	1.126	2.8150
80.	KZG107	1.042	2.6050
81.	KZG108	0.921	2.3025
82.	KZG109	0.903	2.2575
83.	KZG110	0.787	1.9675
84.	KZG112	0.997	2.4925
85.	KZG113	1.016	2.5400
86.	KZG114	1.814	4.5350
87.	KZG115	0.916	2.2900
88.	KZG116	0.926	2.3150
89.	KZG117	1.026	2.5650
90.	KZG118	1.023	2.5575
91.	KZG120	0.932	2.3300
92.	KZG122	1.212	3.0300
93.	KZG123	0.924	2.3100
94.	KZG124	1.424	3.5600
95.	KZG125	1.536	3.8400
96.	KZG126	1.014	2.5350
97.	KZG127	1.265	3.1625
98.	KZG128	1.048	2.6200
99.	KZG129	1.220	3.0500

100.	KZG130	1.232	3.0800
101.	KZG131	1.168	2.9200
102.	KZG132	0.930	2.3250
103.	KZG133	1.106	2.7650
104.	KZG134	1.419	3.5475
105.	KZG135	1.135	2.8375
106.	KZG136	0.979	2.4475
107.	KZG137	0.878	2.1950
108.	KZG138	1.123	2.8075
109.	KZG139	1.005	2.5125
110.	KZG141	0.874	2.1850
111.	KZG142	1.176	2.9400
112.	KZG143	0.984	2.4600
113.	KZG144	0.875	2.1875
114.	KZG145	0.863	2.1575
115.	KZG146	1.066	2.6650
116.	KZG147	1.104	2.7600
117.	KZG148	0.928	2.3200
118.	KZG149	1.497	3.7425
119.	KZG150	1.154	2.8850
120.	KZG151	0.986	2.4650
121.	KZG152	0.941	2.3525
122.	KZG153	1.302	3.2550
123.	KZG154	1.673	4.1825
124.	KZG155	1.487	3.7175
125.	KZG156	1.162	2.9050

126.	KZG157	1.351	3.3775
127.	KZG160	1.603	4.0075
128.	KZG161	1.497	3.7425
129.	KZG162	1.095	2.7375
130.	KZG163	1.284	3.2100
131.	KZG164	0.893	2.2325
132.	KZG166	0.935	2.3375
133.	KZG167	0.810	2.0250
134.	KZG168	0.926	2.3150
135.	KZG169	0.820	2.0500
136.	KZG170	1.168	2.9200
137.	KZG171	1.056	2.6400
138.	KZG172	1.029	2.5725
139.	KZG173	0.972	2.4300
140.	KZG174	1.085	2.7125
141.	KZG175	0.888	2.2200
142.	KZG176	1.145	2.8625
143.	KZG177	0.912	2.2800
144.	KZG178	1.394	3.4850
145.	KZG179	1.133	2.8325
146.	KZG180	0.832	2.0800
147.	KZG181	1.051	2.6275
148.	KZG182	0.932	2.3300
149.	KZG183	1.036	2.5900
150.	KZG184	0.919	2.2975
151.	KZG185	1.155	2.8875



152.	KZG186	1.066	2.6650
153.	KZG187	0.945	2.3625
154.	KZG188	1.036	2.5900
155.	KZG189	1.284	3.2100
156.	KZG190	1.325	3.3125
157.	KZG191	1.398	3.4950
158.	KZG192	0.837	2.0925
159.	KZG193	0.952	2.3800
160.	KZG194	0.867	2.1675
161.	KZG195	0.963	2.4075
162.	KZG196	1.117	2.7925
163.	KZG197	1.091	2.7275
164.	KZG198	1.059	2.6475
165.	KZG199	0.946	2.3650
166.	KZG200	1.001	2.5025
167.	KZG201	1.194	2.9850
168.	KZG202	0.957	2.3925
169.	KZG203	1.104	2.7600
170.	KZG204	1.358	3.3950
171.	KZG206	1.083	2.7075
172.	KZG207	0.916	2.2900
173.	KZG208	0.906	2.2650
174.	KZG209	0.924	2.3100
175.	KZG210	0.946	2.3650
176.	KZG211	0.788	1.9700
177.	KZG212	1.284	3.2100

178.	KZG213	1.021	2.5525
179.	KZG214	1.369	3.4225
180.	KZG215	1.023	2.5575
181.	KZG216	0.946	2.3650
182.	KZG217	0.948	2.3700
183.	KZG218	0.926	2.3150
184.	KZG219	0.897	2.2425
185.	KZG221	0.826	2.0650
186.	KZG222	0.862	2.1550
187.	KZG223	0.928	2.3200
188.	KZG224	0.934	2.3350
189.	KZG226	1.149	2.8725
190.	KZG227	0.942	2.3550
191.	KZG228	1.049	2.6225
192.	KZG229	1.015	2.5375
193.	KZG230	0.904	2.2600
194.	KZG231	1.247	3.1175
195.	KZG232	1.000	2.5000
196.	KZG233	0.957	2.3925
197.	KZG234	1.381	3.4525
198.	KZG236	1.271	3.1775
199.	KZG237	0.903	2.2575
200.	KZG238	0.868	2.1700
201.	KZG239	0.848	2.1200
202.	KZG240	1.052	2.6300
203.	KZG241	1.039	2.5975

204.	KZG242	0.955	2.3875
205.	KZG243	1.127	2.8175
206.	KZG245	1.077	2.6925
207.	KZG246	1.158	2.8950
208.	KZG247	1.089	2.7225
209.	KZG249	1.173	2.9325
210.	KZG250	0.859	2.1475
211.	KZG251	0.922	2.3050
212.	KZG252	0.899	2.2475
213.	KZG253	0.868	2.1700
214.	KZG254	0.898	2.2450
215.	KZG255	1.031	2.5775
216.	KZG256	1.253	3.1325
217.	KZG257	0.988	2.4700
218.	KZG258	1.052	2.6300
219.	KZG259	1.088	2.7200
220.	KZG260	1.042	2.6050
221.	KZG262	1.009	2.5225
222.	KZG263	1.011	2.5275
223.	KZG264	1.085	2.7125
224.	KZG265	0.810	2.0250
225.	KZG266	0.885	2.2125
226.	KZG267	0.935	2.3375
227.	KZG268	1.277	3.1925
228.	KZG269	0.966	2.4150
229.	KZG270	0.895	2.2375

230.	KZG272	0.891	2.2275
231.	KZG273	0.899	2.2475
232.	KZG277	1.054	2.6350
233.	KZG278	1.296	3.2400
234.	KZG279	1.185	2.9625
235.	KZG280	1.194	2.9850
236.	KZG282	1.135	2.8375
237.	KZG283	0.796	1.9900
238.	KZG284	0.827	2.0675
239.	KZG285	0.832	2.0800
240.	KZG287	0.969	2.4225
241.	KZG288	1.391	3.4775
242.	KZG289	1.056	2.6400
243.	KZG290	1.048	2.6200
244.	KZG291	1.135	2.8375
245.	KZG292	1.121	2.8025
246.	KZG293	0.832	2.0800
247.	KZG294	1.239	3.0975
248.	KZG296	0.952	2.3800
249.	KZG297	1.182	2.9550
250.	KZG298	1.113	2.7825
251.	KZG299	0.941	2.3525
252.	KZG300	1.247	3.1175

**Appendix 9: Germplasm Exchange Programme with other states of our country:**



**Collection of kala zeera accessions from different villages of Gurez.**



**Establishment of Kala zeera Germplasm Bank at Gurez**



**Planting Kala zeera trial at KVK, Kinnaur HP**



**Planting of Germplasm evaluation trial at Shaung village, Kinnaur Himachal Pradesh**

**Planting of zeera trials at Kinnaur & Shaung under Germplasm Exchange Programme**