

# A strategy for the development of global chickpea composite collection for diversity studies in SP1CL1



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# Partners



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# Some facts about chickpea

- The third most important food legume grown in about 10 million ha.
- 95% of the area in developing countries.
- Two types – *Desi* and *Kabuli*; *Desi* accounts for about 85% area.



# Origin and Biology

- Center of origin Anatolia in Turkey
- One cultivated and 42 wild (8 annual, 34 perennial) species
- All species are diploid with  $2n=16$  chromosomes
- Highly self-pollinated
- Gene pool of chickpea
  - Primary : *C. arietinum*, *C. reticulatum*
  - Secondary : *C. echinospermum*
  - Tertiary : Remaining 6 annual and 34 perennial species

# Diversity of Chickpea Germplasm Accessions in the Field



# Top 10 countries that have large area under chickpea, and production and productivity of the crop there (FAO 2003)

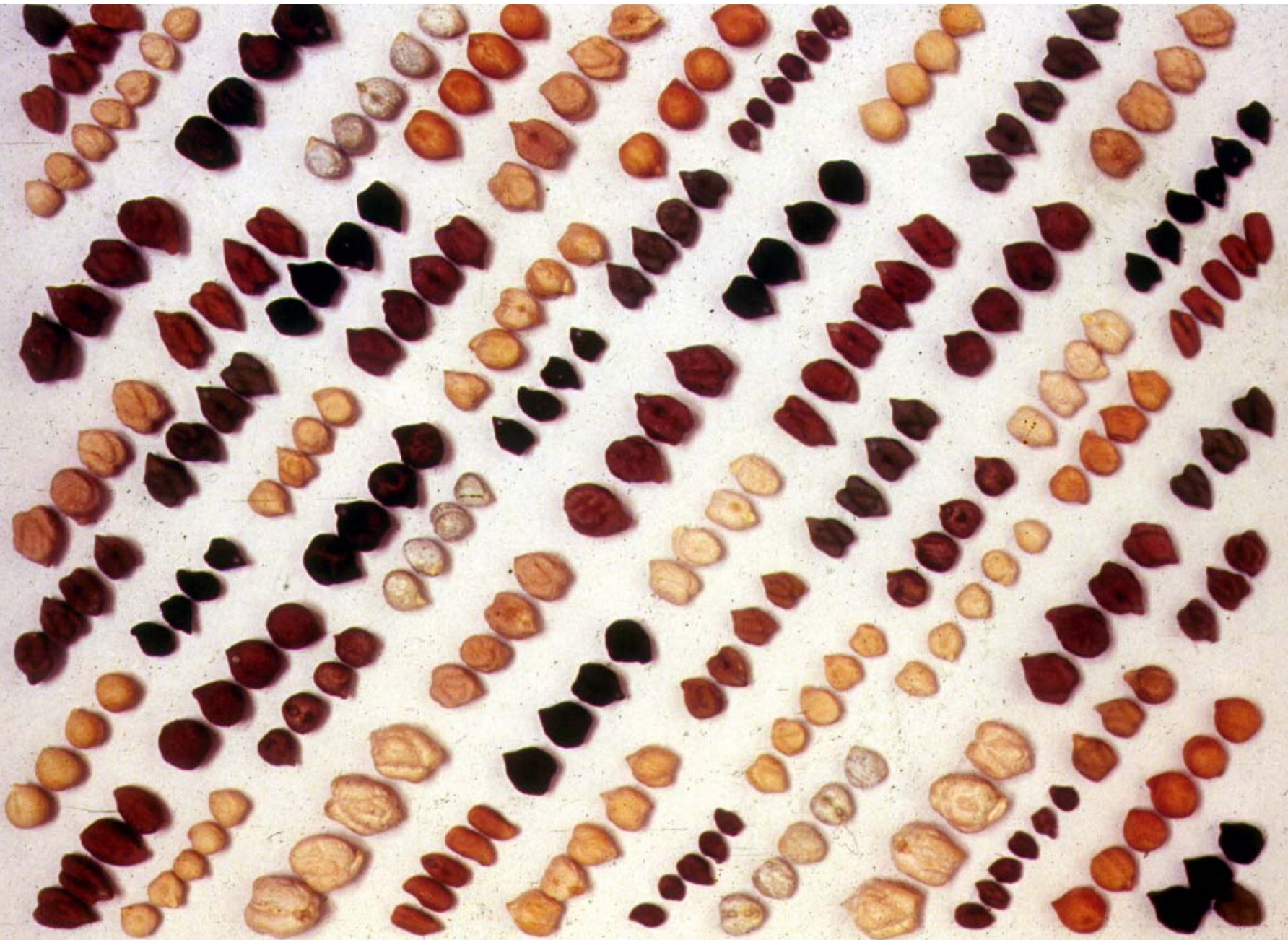


Country	Area (000 ha)	Production (000 mt)	Yield (Kg/Ha)
India	5670	4130	728
Pakistan	1679	672	400
Syria	995	87	873
Iran	750	255	340
Turkey	650	600	923
Australia	217	199	917
Myanmar	200	200	1000
Ethiopia	196	180	921
Mexico	150	240	1600
Spain	78	64	825
<b>World</b>	<b>10,374</b>	<b>7,122</b>	<b>686</b>



# Single vs Twin Pod Trait in Chickpea

# Diversity of Chickpea Germplasm Seeds





***Cicer cuneatum*,  
an annual wild  
species.**

***Cicer microphyllum*, a perennial species**



*Cicer  
microphyllum*  
(ICCW 50)

# Some facts about of chickpea germplasm

## Major centers holding germplasm

**ICRISAT : 17,123 accessions (FAO designated 16 961) from 44 countries**

**ICARDA : 12,032 accessions (FAO designated 8872) from 59 countries**

**USDA : 4662 accessions from 45 countries**

**NBPGR : 3830 accessions**

**VIR : 2293 accessions**





# Major centers holding germplasm of wild *Cicer* species

**ICARDA : 268 accessions representing 10 species**

**USDA : 173 accessions representing 20 species**

**ICRISAT : 135 accessions representing 18 species (8 annual and 10 perennials)**

# Some facts about use of chickpea germplasm in crop improvement

- From 1974 until July 2004 - ICRISAT genetic resources supplied:

- 
- 169 705 samples (15 897 accessions) to scientists in ICRISAT
  - 65 655 to scientists in India (14 112 accessions)
  - 53 637 samples (15 854 accessions) to scientist of 83 countries

- What about use of the germplasm in crop improvement?



# **Use of chickpea germplasm in crop improvement - at ICRISAT**



- In last 24 years (1978-2001) 3430 chickpea breeding lines developed
- 12184 (563 unique) parents used
- 801 (83 unique) germplasm used
- 22 (5 unique) wild accessions used
- L 550 (847 times) and K 850 (808 times) used most widely



# **Use of chickpea germplasm in crop improvement - in India**

- **184 breeding lines evaluated in 2000-2001 season in the chickpea network in India.**
- **284 cultivars/breeding lines used in developing these breeding lines.**
- **13 germplasm lines used (mostly for stress resistance).**

# Progress in SP1C2

Genotypes selected : 288

ICRISAT: 211 (mini-core collection)

ICARDA: 57 cultivated

20 wild (13 *C. reticulatum*,  
7 *C. echinospermum*)





# Composite collection of chickpea-Progress



- At ICRISAT Chickpea core collection (Upadhyaya et al. 2001).
- Data on 16 991 accessions, geographical descriptors and 13 quantitative traits.
- Core collection of 1956 accessions-1465 (74.9%) Desi, 433 (22.1%) Kabuli, and 58 (3.0%) intermediate types.
- Phenotypic diversity in core collection assessed (Upadhyaya et al. 2002).

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# Mini-Core collection



- 1956 core accessions evaluated for 22 morphological and agronomic traits in the 1999/2000 postrainy season.
- Mini-core collection consisting 211 accessions developed (Upadhyaya and Ortiz 2001).
- Mini-core-159 Desi (75.4%), 44 Kabuli (20.9%), and 8 intermediate (3.8%).
- Now for most of our studies at ICRISAT and several NARS, mini-core is the point of entry to germplasm.



# Composite collection of chickpea-Progress



Contd...

## Sampling from ICARDA collection

- Three criteria-Unique to ICARDA, FAO designated, Sufficient seed.
- 5042 accessions of cultivated chickpea germplasm selected.
- Of these catalogue data for 3628 accessions available and further evaluation data for 2527 accessions.
- Data separated by year.
- Used data on 16 quantitative traits and Upadhyaya et al (2001) approach.



# Composite collection of chickpea-Progress

- 709 accessions (including 57 earlier accessions) of cultivated chickpea selected.
- Twenty accessions of two wild species, *C. reticulatum* (13 accessions) and *C. echinospermum* (7 accessions) selected.

# Chickpea composite collection

ICRISAT : 2271 accessions

Type of material	Number of accessions	Type of material	Number of accessions
<b>Core collection</b>	<b>1956</b>	<b>Abiotic stresses</b>	<b>30</b>
<b>Cultivars/breeding lines</b>	<b>39</b>	Drought	10
<b>Biotic stresses</b>	<b>131</b>	Cold	12
Fusarium wilt	50	High temperature	4
Dry root rot	6	Salinity	4
Black root rot	8	<b>Trait specific</b>	<b>80</b>
Botrytis grey mold	8	High input response	4
Ascochyta blight	13	Early maturity	25
Collar rot	9	Nodulation	8
Stunt	8	Seed size	18
Nematode	8	Double poded	8
Helicoverpa	16	Multi seeded	7
Leaf minor	5	High protein	10
		<b>Morphological variant</b>	<b>35</b>

# Chickpea composite collection

**ICARDA : 729 accessions**

Type of material	Number of accessions
Random selection category	497
Selection based on evaluation data	212
Wild species	20
<b>Grand total ICRISAT + ICARDA</b>	<b>3000</b>

# Constraints and difficulties



- There are differences in descriptive parameters used by the various institutes.
- Inadequate data on the reaction of germplasm to biotic and abiotic stresses, and nutritional quality traits.



# Genotyping Chickpea Germplasm

## Genotypes

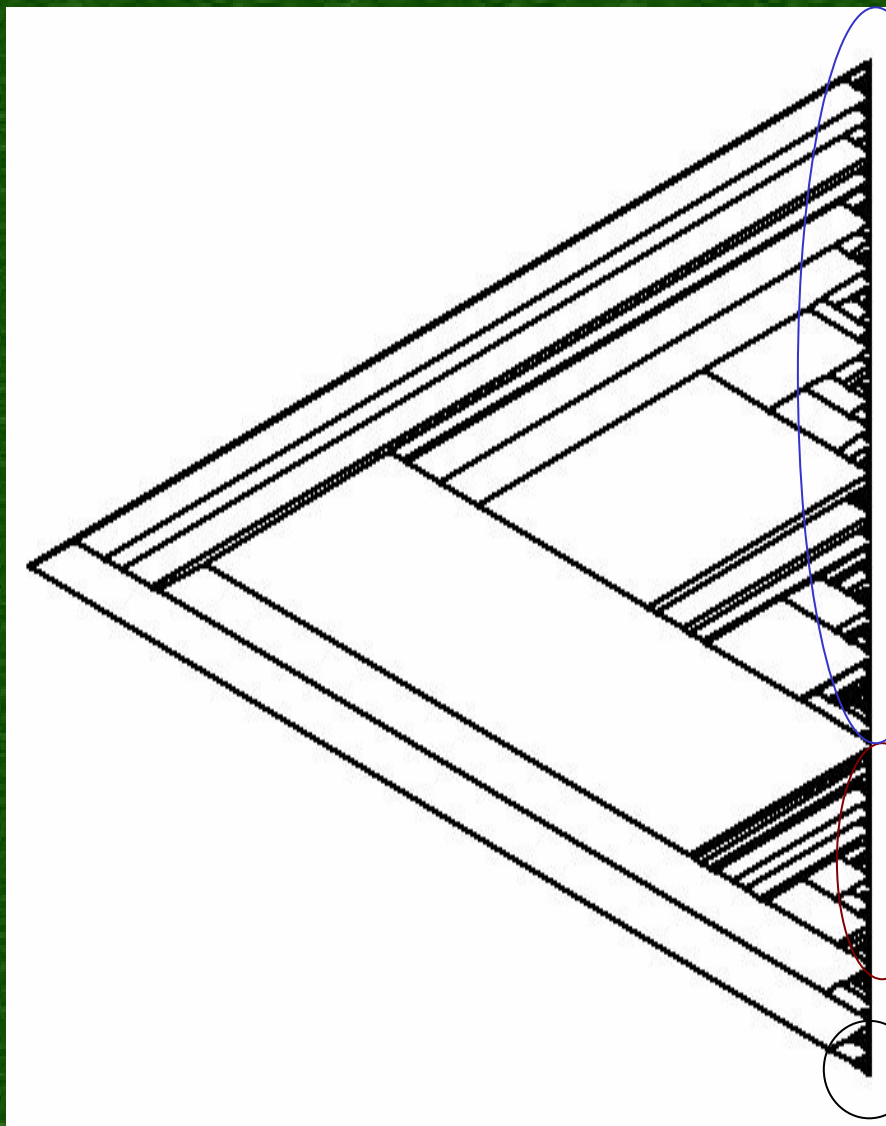
- 211 ICRISAT mini-core accessions
- 57 ICARDA Kabuli accessions
- 20 ICARDA wild species  
(*C. echinospermum* and *C. reticulatum*)

## Markers

- Assesses with 35 SSR markers



- **Analyzed 31 SSR markers:  
27 trinucleotide repeat motif and  
4 dinucleotide motifs**
- **Number of allele detected per  
marker ranged between 6 - 44**
- **Total number of alleles assessed  
779**
- **Data-set consisted of less than  
5% missing values**



Mainly minicore  
accessions and  
few ICARDA

Mainly ICARDA  
accessions

ICARDA wild  
germplasm

**UPGMA clustering of 285 chickpea accessions with 31  
SSR markers based on Goldstine (1995) distance matrix.**



**Thank You!**



# **Geographical Pattern of Diversity in Chickpea**





# Chickpea Germplasm at ICRISAT

- 16 820 accessions from 43 countries were used for this study.
- 172 accessions excluded - 3 from Australia because of the low seed number, and another 169 accessions, due to lack of information on origin.
- Desi - 12 779 (75.3%), Kabuli - 3561 (20.9%), and intermediate - 637 (3.8%).



# Regions



- **Eight regions (43 countries)**
- **Five regions in Asia**
  - **East Asia, west Asia, southeast Asia, south Asia, Mediterranean**
- **One each in Africa, America, and Europe**



# Morphological Descriptors

- Seven morphological descriptors.
- From 1974 to 1998, ICRISAT center, India.
- In 25 years number of entries ranged from 3984 in 1974 to 64 in 1998 (number depended upon acquisition of new accessions and availability of sufficient seed).
- Six morphological descriptors, flower colour, growth habit, seed colour, seed shape, seed texture, and dots on seed testa - 16 820 accessions.
- Plant colour-14 683 accessions.



# Agronomic Traits

- In all the 25 years, augmented design was used.
- Three control cultivars, JG 62, L 550, and G 130 (1974-1980) and Annigeri, L 550, and G 130 (1981-1998).
- The control cultivars were repeated after every 20 test entries from 1974 to 1979 and after every 10 test entries from 1980 to 1998.

# Agronomic Traits

- 13 agronomic traits: plant basis- plant height, plant width, number of basal primary branches, apical primary branches, basal secondary branches, apical secondary branches, and tertiary branches, days to maturity, number of pods per plant, number of seeds per pod, and 100-seed weight (g) and yield.
- Plot basis: days to 50% flowering, days to maturity and seed yield – all accessions.

# Disease Resistance

## Reaction to fusarium wilt - 12 549 accessions

- Scale - 1 (resistant, 0-10% diseased plants).
- Scale - 2 (11- 40% diseased plants).
- Scale - 3 (> 41% diseased plants).



# Data Analysis

- **Statistical analysis performed in three stages using residual maximum likelihood (REML) approach.**
- **First stage - separate analysis for each of the 25 years. Predicted means of each of entries obtained.**
- **Second stage - combined analysis of 25 year data to estimate components of variance due to entry (genotype) and entry x year interactions.**

# Data Analysis

- **Third stage** - analysis using regions (as fixed) and years (as random) were considered using predicted mean of entry from first stage analysis to determine importance of regions and region x year interactions.
- The means of different regions for all traits were compared using the Newman-Keuls procedure (Newman, 1939; Keuls, 1952).
- The homogeneity of variances of regions was tested using Levene's test (Levene, 1960).

# Data Analysis

- Shannon-weaver diversity index ( $H'$ ) used as a measure of phenotypic diversity for each trait.
- $H'$  for each region and trait was calculated.
- By pooling various characters across geographical regions, the additive properties of  $H'$  were used to evaluate the diversity of the regions and characters within populations.
- PCA was performed. Cluster analysis (Ward, 1963) was performed using scores of first four principal components.



# Regional Imbalances



## *Over representation*

- South Asia is represented by the largest number of accessions (7873 accessions, 46.8% of the total).
- West Asia (5564, 33.1%) in the ICRISAT genebank.
- India in South Asia with 7174 accessions (91.1% of the region).
- Iran with 4838 accessions (87.0% of the region) in west Asia are the two major germplasm contributing countries.

# Regional Imbalances

## *Under representation*

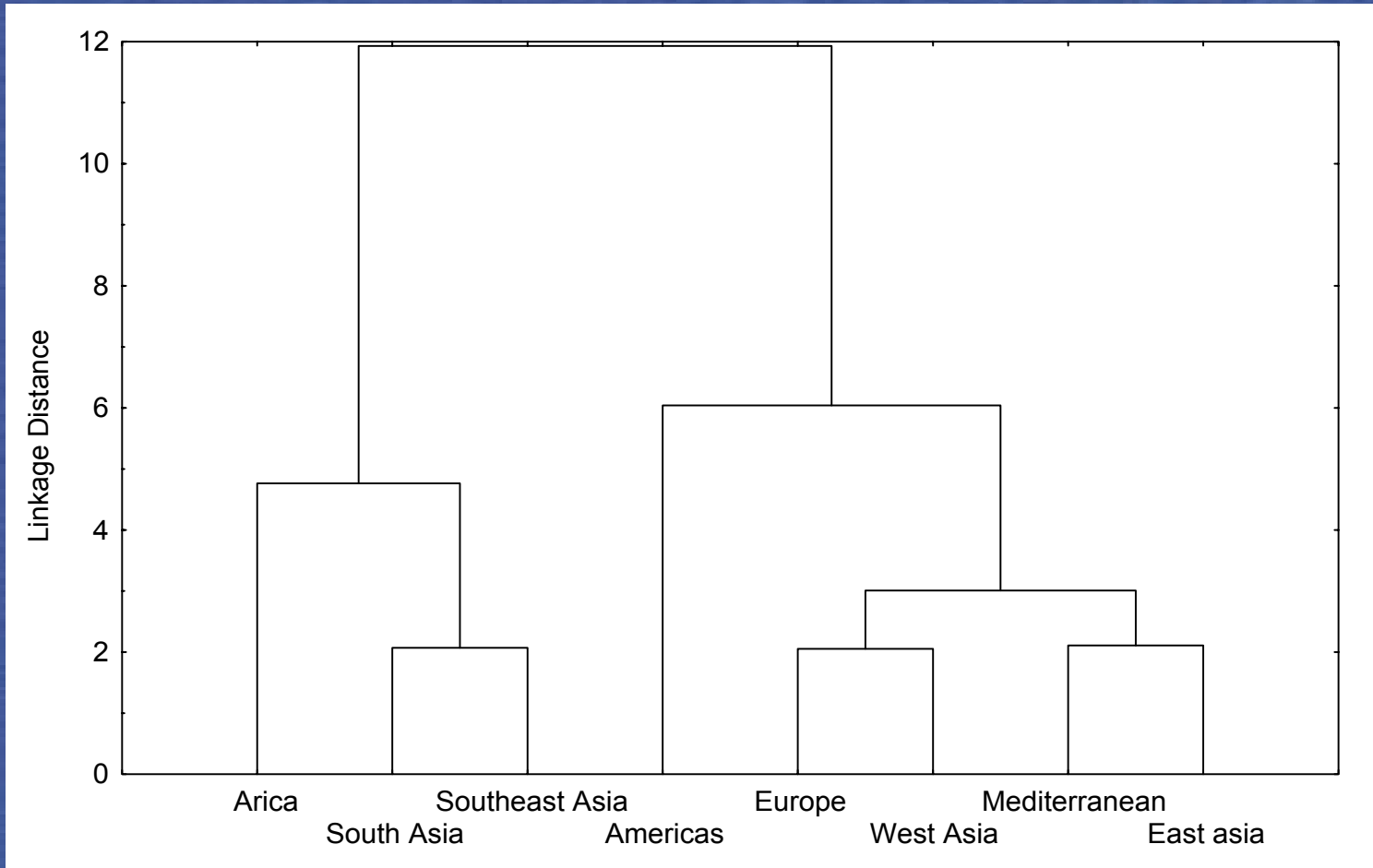
- The Mediterranean, which is one of the two primary centers of diversity, contributed only 1225 accessions (7.3%).
- Ethiopia which is the secondary center of diversity contributed only 928 accessions (5.5%).

# Regional Diversity

- The West Asia region had highest pooled  $H'$  for morphological descriptor traits ( $0.39 \pm 0.070$ ) and agronomic traits ( $0.57 \pm 0.012$ ).
- Seed colour ( $0.62 \pm 0.083$ ) among morphological traits and days to 50% flowering ( $0.58 \pm 0.025$ ) among agronomic traits had highest pooled  $H'$ .
- Over all the 21 traits, west Asia ( $0.50 \pm 0.033$ ) had the highest  $H'$  and southeast Asia least pooled  $H'$  ( $0.31 \pm 0.035$ ).

# Regional Diversity

- A hierarchical cluster analysis conducted on the first three PC scores (total variation accounted 90.9%) resulted in two clusters.
- Africa, South Asia, and Southeast Asia grouped together to form cluster 1.
- The Americas, Europe, West Asia, Mediterranean, and East Asia formed cluster 2.



Dendrogram of eight regions for the entire chickpea germplasm based on first three principal components.



# Subsequent Analyses and Studies

- Chickpea core collection (Upadhyaya et al. 2001).
- Data on 16 991 accessions, geographical descriptors and 13 quantitative traits.
- Core collection of 1956 accessions-1465 (74.9%) Desi, 433 (22.1%) Kabuli, and 58 (3.0%) intermediate types.
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***Thank You!***