International Quinoa Conference 2016:

Quinoa for Future Food and Nutrition Security in Marginal Environments

Dubai, 6-8 December 2016

www.quinoaconference.com

Experimenting with quinoa: the Indian experience

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Introduction

INDIA

- **Seventh largest country in the world.**
- **Area: 4.4 million sq. km.**
- **Total population: 1.26 Billion.**
- **4th Largest Economy in the world in PPP.**
- **GDP Growth rate of 7.3%- Highest in the world.**
- **Enormous diversity in agroclimatic regions & edaphoclimatic conditions.**

Quinoa Introduction in India

With respect to population

- **Population: predicted to rise to 1.53 billion by 2030.**
- **23.6% of Indian population, or about 276 million people, lived below $1.25 per day (World Bank 2011).**
- **India is 20th amongst leading countries with a serious hunger situation (Global Hunger Index Report 2015).**
- **India: ranked 67 among the 80 nations having the worst hunger situation.**
- **Widespread malnutrition and protein deficiency.**

With respect to agriculture

- **Salinity and alkalinity: 6.73 million ha of land.**
- **Acidity: 25 million ha of land is having pH below 5.5 and 23 million ha fall under the pH range of 5.6 - 6.5.**
- **Drought: Dryland area of 228.3 million hectares (about 69.6% of total area).**

History of Quinoa Research in India

1990s: Research on quinoa was initiated at the National Botanical Research Institute (CSIR-NBRI), Lucknow.

Lucknow: 26.5°N, 80.5°E, 120 m asl

2000: Research intensified as part of a coordinated effort by different departments, namely genetics and plant breeding, lipid chemistry, plant pathology, experimental taxonomy and biomass biology.

Germplasm: United States Department of Agriculture (USDA) and IPK Gatersleben, Germany.

Objective

- **Assess the potential of quinoa as a n alternative crop for marginal lands.**

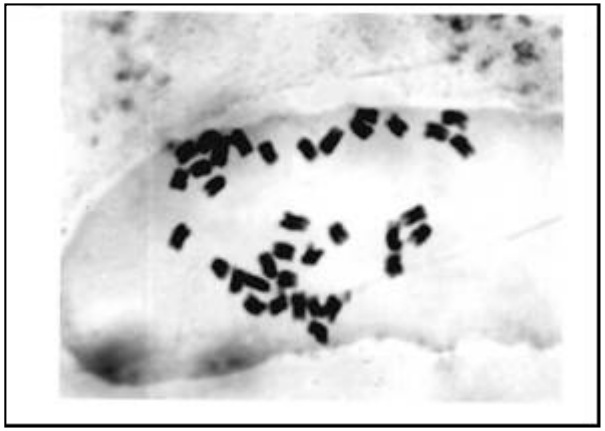
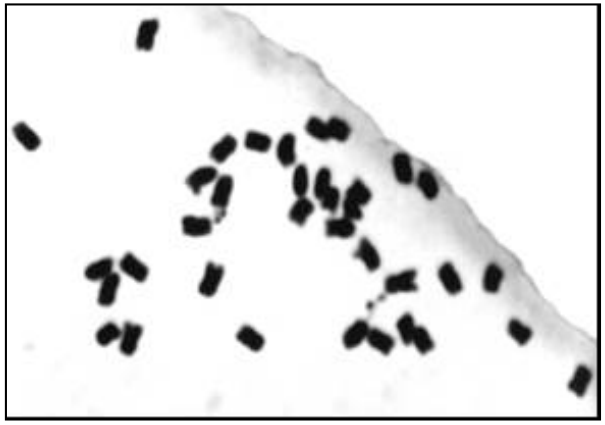
Parameters of research

- **Cytological studies and karyotyping.**
- **Nuclear DNA content and genome size.**
- **Floral structure and Breeding system.**
- **Field Trials & Breeding- Genetic diversity (morphological and molecular), phylogenetic analysis, correlation and path analysis.**
- **Nutritional studies.**
- **Pathology**
- **Phytoremediation**

Results

[I] Cytological studies and karyotyping

- **Classical cytogenetic studies involving 7 accessions.**


- **Symmetry index (TF%): 43.9% (PI 584524, most asymmetrical) to 47.4% (CHEN 58/77, most symmetrical).**
- **One satellite pair: morphologically similar in all the accessions being median (m) or median-submedian (msm).**
- **First chromosome: either m or msm with arm ratios varying between 1.18-1.56, while 4^{th}, 9^{th} and 18^{th} pairs were the most conserved in being median in the accessions studied.**

Results

Table 1. Karyotype arrangements in 9 taxa of *Chenopodium* species.

Taxa	2n	No. of satellite pairs	Ratio of longest/ shortest x±SE	Maximum r-index x±SE	Symmetry index[a]	Karyotypic formula	Class. (Stebbins 1958)
C. quinoa PI 587173	36	1(2)[b]	2.12±0.04	1.58(7)[b]±0.05	44.7	4M+9m+5msm	1b
C. quinoa PI 584524	36	1(8)	1.67±0.02	1.86(10)±0.02	43.9	6M+4m+6msm+2sm	1a
C. quinoa PI 596498	36	1(2)	1.64±0.02	1.64(8)±0.04	44.7	4M+6m+8msm	1a
C. quinoa PI 510537	36	1(12)	2.11±0.03	1.56(14)±0.04	46.2	5M+8m+5msm	1b
C. quinoa CHEN 71/78	36	1(8)	1.73±0.06	1.68(5)±0.05	44.8	7M+4m+7msm	1a
C. quinoa CHEN 58/77	36	1(3)	2.13±0.04	1.50(1)±0.02	47.4	10M+7m+1msm	1b
C. quinoa CHEN 33/84	36	1(2)	2.45±0.02	1.64(3)±0.04	46.2	9M+6m+3msm	1b
C. berlandieri subsp. nuttalliae PI 568156	36	1(3)	1.63±0.03	1.58(3)±0.02	44.1	4M+6m+8msm	1a
C. bushianum Ames 22376	54	2(3,18)	2.65±0.03	1.86(26)±0.04	45.1	8M+12m+5msm+2sm	1b

[a]Symmetry index (TF%)= (total sum of short arm length/total sum of chromosome length)x 100.

[b]Number within parenthesis denotes the chromosome in order of decreasing size.

Results

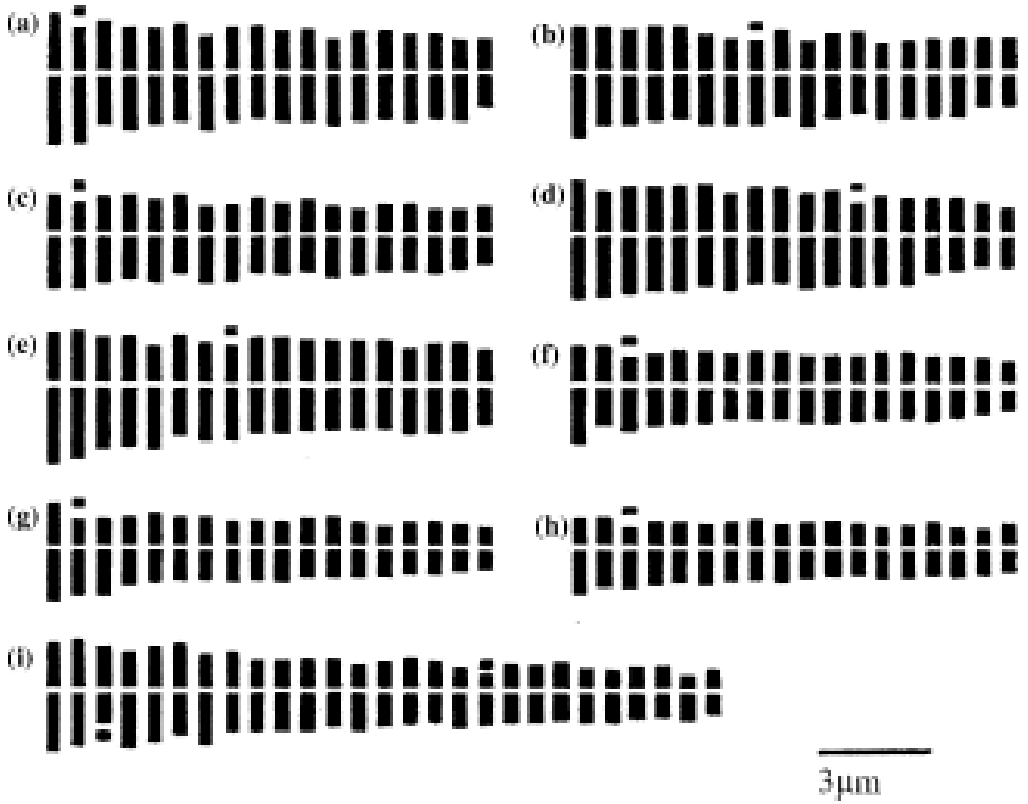


Figure 1. Idiograms of (a*) C. quinoa* PI 587173, (b) *C. quinoa* PI 584524, (c) *C. quinoa* PI 596498, (d) *C. quinoa* PI 510537, (e) *C. quinoa* CHEN 71/78, (f) *C. quinoa* CHEN 58/77, (g) *C. quinoa* CHEN 33/84, (h) *C. berlandieri subsp. nuttalliae* PI 568156, (i) *C. bushianum* 22376.

Results

Karyotypic studies

- ***C. quinoa*** **(4x) showed minor but consistent differences in the arm ratio of various chromosomes within the complements of different accessions.**

- **Quinoa chromosomes could be arranged in 18 pairs that suggest its allotetraploid nature.**

- **Karyotype of *C. berlandieri subsp. nuttalliae* (4x) was basically similar to that of *C. quinoa*.**

- ***C. bushianum*** **(6x) was distinctly different from the above two species in showing highest ratio between longest and shortest chromosomes.**

Results

[II] Nuclear DNA content

- **Microdensitometry- wavelength of 565 nm.**
- **DNA content in 21 accessions of quinoa and 2 accessions of *C. berlandieri* subsp. *nuttalliae*, along with several other species.**
- ***C. quinoa*: 1.02-fold variation in 4C DNA amounts (Pachytene stage) ranging from 6.34 to 6.47 pg.**
- ***C. berlandieri* subsp. *nuttalliae*: 5.79 to 5.90 pg.**
- **DNA amount of *C. berlandieri* subsp. *nuttalliae*: 8.31% less than the mean DNA amount of *C. quinoa*.**
- **The significant differences in DNA amounts of *C. quinoa* and *C. berlandieri* subsp. *nuttalliae* show that both of them have evolved in widely separated geographical areas subsequent to their independent origin.**
- **Small genome size: Species are evolutionarily flexible, allowing them to colonize new and more diverse environments.**

Results

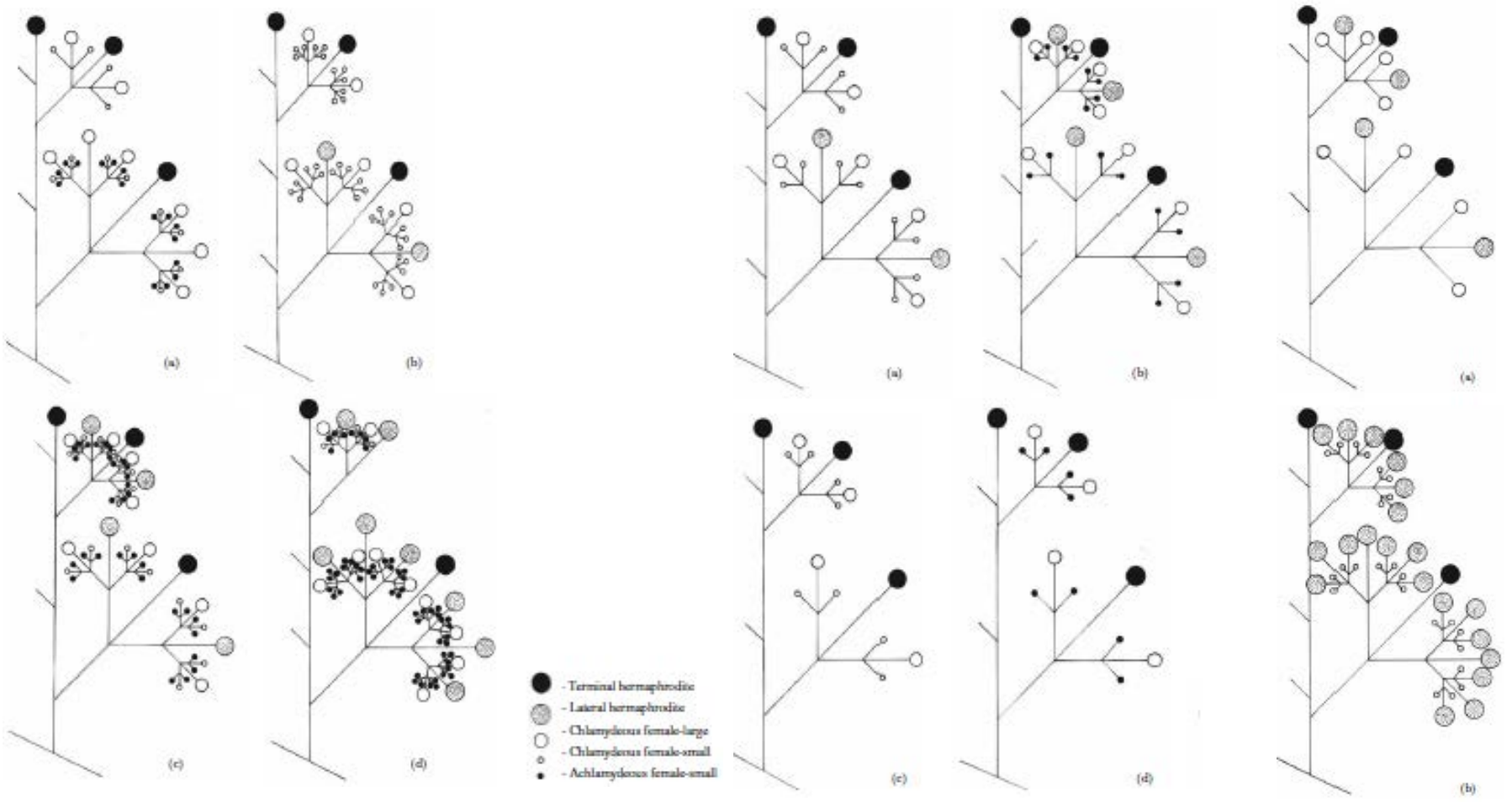
[III] Floral structure and breeding system

- **Quinoa: Gynomonoecious i.e. the female and perfect flowers are present on the same individual.**

- **Floral structure: Flowers can be divided into 5 types based on their being hermaphrodite or female, presence or absence of perianth and size.**
  I. Terminal hermaphrodite flower
  II.Lateral hermaphrodite flower
  III.Chlamydeous female flowers-large
  IV.Chlamydeous female flowers-small
  V.Achlamydeous flowers-small

Results

10 types of flower clusters or glomeruli



Breeding implications: The ones having low frequency of hermaphrodite flowers can be used in breeding programs as the quinoa flowers being rather small are not amenable to emasculation.

Results

[IV] Genetic variability- Morphological, Biochemical and Molecular

Genetic variability and interrelationships among morphological and quality traits

27 germplasm lines of *Chenopodium quinoa* and 2 lines of *C. berlandieri subsp. nuttalliae*

Results

Mean performance of 29 lines for 12 morphological traits in *Chenopodium*

Germplasm lines	Origin	Days to flowering	Days to maturity	Plant height (cm)	Leaf area (cm^2)	Primary branches/ plant	Inflorescence length (cm)	Inflorescence/ plant	Seed size (mm)	1000 seed weight (g)	Dry weight/ plant (g)	Harvest index	Seed yield (t/ha)
C. quinoa CHEN 58/77	–	73.55	117.67	45.41	15.71	16.56	2.93	41.19	1.58	1.81	6.31	1.07	2.11
C. quinoa CHEN 67/78	Puno, Peru	74.55	119.44	59.63	6.12	16.70	1.71	91.63	1.34	0.78	5.75	0.74	3.75
C. quinoa CHEN 71/78	Bolivia	79.33	131.67	46.33	26.94	15.44	3.39	127.73	1.97	2.85	7.21	1.43	3.27
C. quinoa CHEN 33/84	–	101.55	144.00	42.33	9.46	16.96	2.42	13.85	1.57	2.07	3.84	1.40	1.33
C. quinoa CHEN 84/79	Cuzco, Peru	86.00	121.67	86.97	17.47	22.11	1.00	117.78	2.21	3.57	10.47	1.32	3.44
C. quinoa CHEN 92/91	Columbia	81.89	123.22	77.49	24.69	14.06	2.25	64.11	2.01	3.70	10.21	0.88	2.25
C. quinoa CHEN 7/81	–	85.11	133.78	123.56	22.14	28.00	4.09	141.55	2.09	3.65	28.00	1.41	9.83
C. quinoa PI 614938	Oruro, Bolivia	71.00	109.33	11.27	5.67	10.00	1.07	11.67	1.73	1.87	1.11	1.06	0.32
C. quinoa PI 478408	La Paz, Bolivia	71.33	109.33	17.67	8.93	8.55	0.84	14.65	2.17	2.87	1.26	1.19	0.47
C. quinoa PI 478414	La Paz, Bolivia	83.66	134.11	78.98	21.53	20.55	1.60	106.48	1.81	3.03	14.00	1.25	6.07
C. quinoa PI 596498	Cuzco, Peru	83.77	129.00	65.87	20.82	17.33	2.47	90.33	2.03	3.08	19.89	0.79	3.93
C. quinoa Ames 13219	La Paz, Bolivia	81.99	129.98	53.96	11.75	19.21	2.64	114.66	2.06	3.54	15.08	0.73	2.80
C. quinoa Ames 13719	New Mexico, USA	82.21	120.28	115.52	25.03	27.74	2.67	98.00	2.15	3.65	32.03	0.99	9.33
C. quinoa PI 587173	Jujuy, Argentina	85.33	125.78	101.03	30.91	16.74	2.25	68.50	2.01	4.09	15.47	0.81	3.17
C. quinoa PI 510532	Peru	86.67	157.11	144.03	22.02	25.55	2.24	138.22	1.51	1.25	52.89	0.29	1.68
C. quinoa PI 614883	Jujuy, Argentina	70.78	109.89	54.89	12.33	21.89	3.61	45.89	1.73	1.77	3.03	0.97	1.00
C. quinoa PI 584524	Chile	81.33	127.00	115.89	29.64	25.00	2.51	137.55	1.58	3.02	29.86	0.90	6.60
C. quinoa Ames 22156	Chile	80.55	126.00	106.44	26.16	20.44	1.60	85.55	1.93	3.51	17.21	1.21	5.03
C. quinoa Ames 13762	New Mexico, USA	79.33	132.44	123.72	5.00	23.00	4.31	136.44	1.83	2.75	35.21	0.94	8.50
C. quinoa PI 614881	Jujuy, Argentina	87.11	127.22	113.00	25.00	24.56	3.01	114.22	2.05	2.94	24.16	1.34	8.25
C. quinoa PI 510537	Peru	84.33	124.00	100.00	14.39	25.44	1.44	136.00	1.78	2.71	13.02	1.32	4.39
C. quinoa PI 510547	Peru	82.11	131.78	66.67	16.02	14.11	2.08	68.92	1.82	3.13	12.67	1.33	4.70
C. quinoa Ames 22158	Chile	80.89	131.11	80.27	23.25	21.24	3.85	40.29	1.95	3.17	12.70	1.18	4.85
C. quinoa PI 510536	Peru	73.78	115.22	31.05	4.42	17.53	1.79	21.03	1.93	2.34	1.38	1.28	0.67
C. quinoa PI 478410	La Paz, Bolivia	82.77	126.78	101.10	17.29	22.61	0.90	118.33	1.80	2.63	29.00	0.43	3.13
C. quinoa PI 433232	Chile	81.00	130.00	108.66	23.01	20.89	4.54	74.22	1.77	2.28	13.11	1.09	3.56
C. quinoa Ames 21909	Oruro, Bolivia	82.55	152.44	82.44	25.87	21.00	2.12	132.22	1.83	3.31	15.97	1.15	9.08
C. berlandieri subsp. *nuttalliae* PI 568155	Mexico	91.33	163.33	139.44	21.44	35.74	6.47	114.78	1.58	1.28	28.94	0.26	2.01
C. berlandieri subsp. *nuttalliae* PI 568156	Mexico	85.33	152.33	135.44	13.53	29.11	4.77	103.39	1.65	1.37	15.05	0.65	2.32
Mean ± S.E.		81.76 ± 1.18	129.51 ± 2.51	83.76 ± 6.79	18.15 ± 1.44	20.62 ± 1.08	2.64 ± 0.24	88.59 ± 7.81	1.84 ± 0.03	2.69 ± 0.15	16.37 ± 2.24	1.01 ± 0.06	4.06 ± 0.52
CD (5%)		2.41	5.14	13.90	2.94	2.21	0.49	15.99	0.06	0.30	4.58	0.12	1.06
CD (1%)		3.26	6.93	18.76	3.97	2.98	0.66	21.57	0.08	0.41	6.18	0.17	1.43
CV		7.82	10.44	43.67	42.75	28.32	49.62	47.48	11.41	31.97	73.85	32.16	68.34

Results

Mean performance of 29 lines for 4 quality traits in *Chenopodium*

Germplasm lines	Origin	Total chlorophyll (mg/g)	Leaf carotenoid (mg/kg)	Seed carotenoid (mg/kg)	Seed protein (%)
C. quinoa CHEN 58/77	–	1.03	389.83	1.73	13.22
C. quinoa CHEN 67/78	Puno, Peru	1.70	531.03	3.12	21.02
C. quinoa CHEN 71/78	Bolivia	1.82	534.80	3.15	19.37
C. quinoa CHEN 33/84	–	0.55	230.23	1.69	16.92
C. quinoa CHEN 84/79	Cuzco, Peru	1.12	414.73	2.30	18.84
C. quinoa CHEN 92/91	Columbia	1.68	521.83	2.00	13.93
C. quinoa CHEN 7/81	–	1.92	632.40	3.30	17.31
C. quinoa PI 614938	Oruro, Bolivia	1.16	338.23	2.84	17.83
C. quinoa PI 478408	La Paz, Bolivia	1.19	330.03	2.74	15.23
C. quinoa PI 478414	La Paz, Bolivia	1.86	588.23	3.88	17.86
C. quinoa PI 596498	Cuzco, Peru	1.65	551.07	2.68	15.09
C. quinoa Ames 13219	La Paz, Bolivia	1.32	421.03	2.02	12.55
C. quinoa Ames 13719	New Mexico, USA	1.36	466.13	1.75	17.71
C. quinoa PI 587173	Jujuy, Argentina	1.85	580.43	3.86	14.66
C. quinoa PI 510532	Peru	1.34	483.13	2.06	14.51
C. quinoa PI 614883	Jujuy, Argentina	1.25	434.67	3.15	19.48
C. quinoa PI 584524	Chile	2.04	669.56	2.87	13.01
C. quinoa Ames 22156	Chile	1.86	611.83	2.81	14.24
C. quinoa Ames 13762	New Mexico, USA	1.60	519.90	2.08	15.47
C. quinoa PI 614881	Jujuy, Argentina	1.42	481.23	3.33	13.89
C. quinoa PI 510537	Peru	1.59	511.77	3.82	19.78
C. quinoa PI 510547	Peru	1.22	416.30	2.35	20.43
C. quinoa Ames 22158	Chile	1.06	414.63	2.40	16.09
C. quinoa PI 510536	Peru	1.09	371.80	2.84	20.39
C. quinoa PI 478410	La Paz, Bolivia	1.43	480.07	1.97	13.08
C. quinoa PI 433232	Chile	1.51	479.47	2.13	14.23
C. quinoa Ames 21909	Oruro, Bolivia	1.55	504.07	3.15	16.20
C. berlandieri subsp. *nuttalliae* PI 568155	Mexico	1.17	601.90	5.52	13.28
C. berlandieri subsp. *nuttalliae* PI 568156	Mexico	1.20	528.50	4.73	14.82
Mean ± S.E.		1.43 ± 0.06	484.09 ± 18.37	2.83 ± 0.16	16.22 ± 0.47
CD (5%)		0.12	37.62	0.32	0.96
CD (1%)		0.16	50.75	0.44	1.29
CV		23.07	20.42	31.80	15.90

Results

- **Seed yield: 0.32 to 9.83 t/ha, higher yields being shown by four Chilean, two US, one Argentinian and one Bolivian accessions.**
- **Seed protein:12.55-21.02% with an average of 16.22 %.**
- **Seed carotenoid: 1.69–5.52 mg/kg**
- **Leaf carotenoid: 230.23-669.57 mg/kg.**
- **Genetic gain: Highest for dry weight/plant, followed by seed yield and inflorescence length.**
- **All morphological traits except days to flowering, days to maturity and inflorescence length exhibited significant positive association with seed yield.**
- **Path analysis: 1000 seed weight had highest positive direct relationship with seed yield (1.057), followed by total chlorophyll (0.559) and branches/plant (0.520).**
- **Total chlorophyll: exerted strongest direct positive effect (0.722) on harvest index, followed by seed yield (0.505) and seed protein (0.245).**

Results

Molecular diversity

RAPD and directed amplification of minisatellite DNA (DAMD) markers- 55 accessions of 14 species of *Chenopodium* (23 of quinoa)

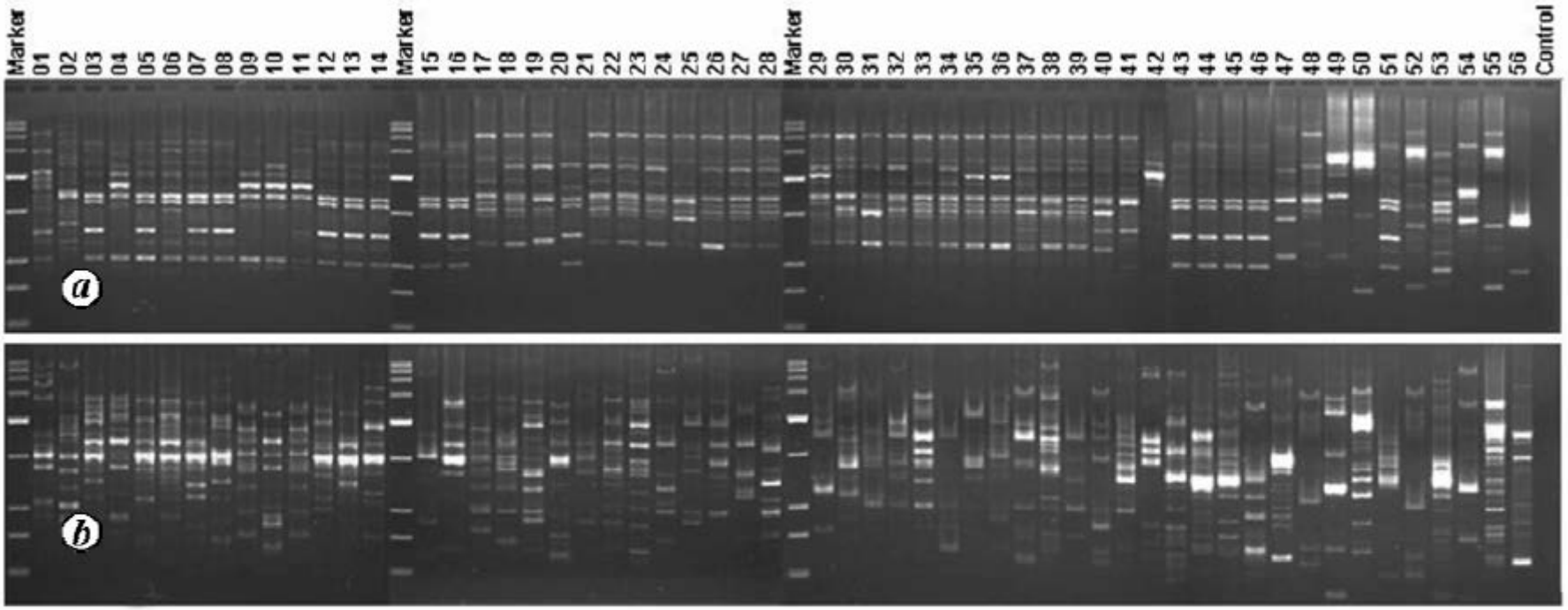
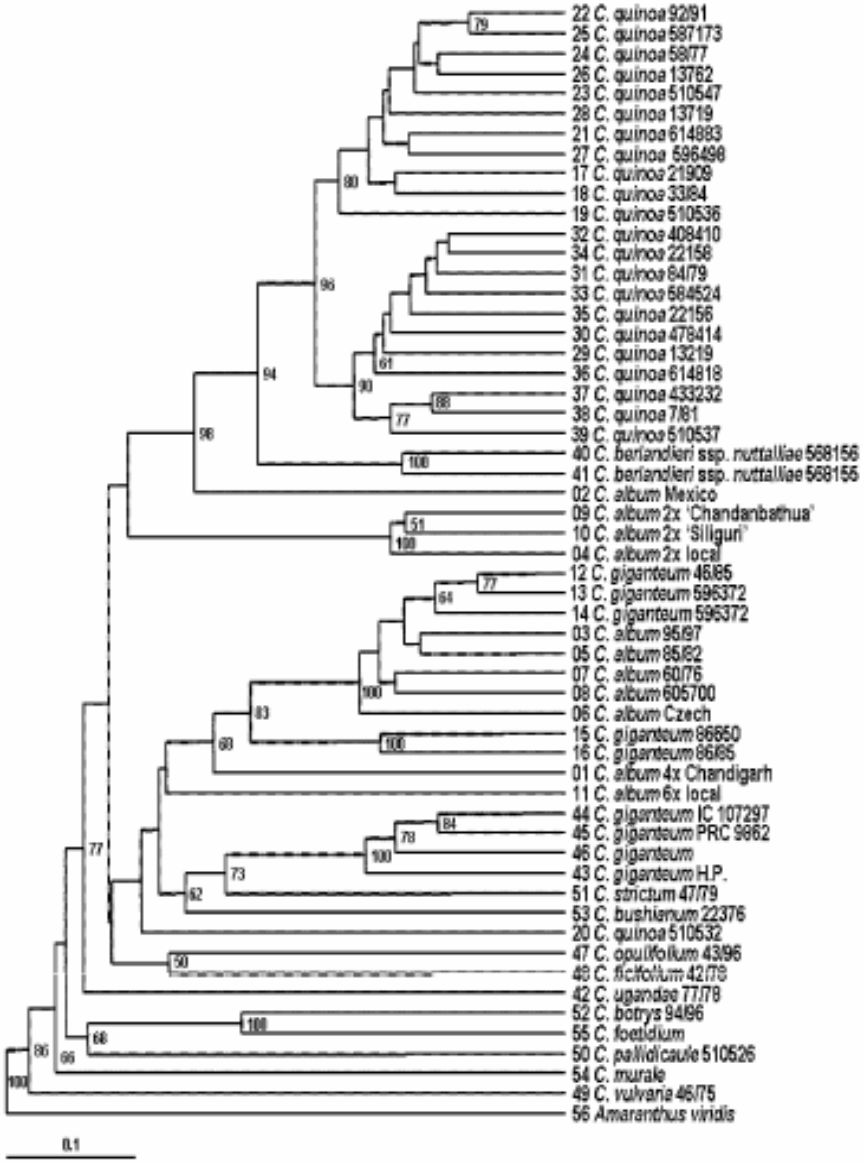


Figure 1. Gel profiles of the *Chenopodium* accessions amplified with RAPD primer OP-N09 (*a*) and DAMD primer HBV (*b*). The lanes indicated by 'Marker' contain low range DNA ruler as molecular weight marker and the lane 'Control' is negative control without adding template DNA in the PCR reaction. The other lanes are marked with the accession numbers as in Table 1. All profiles were resolved in 1.5% agarose gels in 0.5*x* TBE at constant voltage.

Results



The first cluster joins all the accessions of *C. quinoa* with *C. berlandieri* subsp. *nuttalliae*, one *C. album* (4*x*) from Mexico and three north Indian 2*x* accessions of *C. album*.

The other clusters comprises mainly 6*x* accessions of *C. album* and *Chenopodium giganteum* forming two subclusters.

Cluster analysis of the combined RAPD and DAMD data.

Results

Evaluation of quinoa for foliage yield

Rationale for study

- Grazing lands have become rare in the Indo-Gangetic Plains.
- Small farmers depend on wild grasses and plants along with hay for feeding the livestock.
- Thus both inadequate availability and inadequate nutritive quality of forage are a major constraint to livestock production in this region.

Experiment

- An accession containing low saponin was used to ascertain up to what extent can foliage yield and quality of foliage be influenced by varying the sowing dates and row spacing for high quality foliage production in C. *quinoa*.
- Split-plot design in each experiment.
- Sowing date as the main plot and row spacing and final harvest dates as subplots.
- Plot size for each subplot was 4 m2.
- Inter-row spacing: 15, 20 and 25 cm.

Results

Effect of sowing date and row spacing on the foliage yield (t/ha)

	Year 1			Year 2		
	15 Nov.	30 Nov.	15 Dec.	20 Nov.	5 Dec.	20 Dec.
Spacing (15 cm)						
I harvest	2.41	2.74	2.89	2.24	2.74	3.32
II harvest	3.88	3.13	2.88	2.34	3.13	2.83
III harvest	4.23	2.14	2.12	4.35	2.92	2.18
IV harvest	1.87	2.07	1.64	3.44	2.67	1.50
Total harvest	12.39	10.08	9.53	12.37	11.46	9.83
Mean	3.10	2.52	2.38	3.09	2.86	2.46
SE±	±0.57	±0.25	±0.31	±0.50	±0.10	±0.39
Spacing (20 cm)						
I harvest	2.82	4.30	3.20	2.05	4.10	3.02
II harvest	4.67	5.10	3.03	2.82	3.83	2.86
III harvest	4.21	2.01	2.04	4.05	3.15	2.24
IV harvest	2.48	2.02	1.56	3.22	2.82	1.48
Total harvest	14.18	13.43	9.83	12.14	13.90	9.60
Mean	3.54	3.36	2.46	3.03	3.47	2.40
SE±	±0.53	±0.79	±0.39	±0.42	±0.29	±0.35
Spacing (25 cm)						
I harvest	2.67	6.24	3.16	2.54	2.28	3.17
II harvest	6.27	6.83	3.05	2.47	4.52	3.03
III harvest	7.20	2.54	2.01	3.85	3.61	2.10
IV harvest	2.85	2.05	1.53	3.68	3.07	1.53
Total harvest	18.99	17.66	9.75	12.54	13.48	9.83
Mean	4.75	4.41	2.44	3.13	3.37	2.46
SE±	±1.16	±1.23	±0.40	±0.36	±0.47	±0.40

Results

Effect of sowing date and row spacing on the foliage yield (t/ha)

	Leaf carotenoid (mg/g)						Leaf protein (g/100 g)					
	Year 1			Year 2			Year 1			Year 2		
	15 Nov.	30 Nov.	15 Dec.	20 Nov.	5 Dec.	20 Dec.	15 Nov.	30 Nov.	15 Dec.	20 Nov.	5 Dec.	20 Dec.
Spacing (15 cm)												
I harvest	0.80	0.94	1.05	0.74	0.87	1.02	3.81	3.86	3.51	3.71	3.78	3.36
II harvest	1.02	1.14	0.99	0.93	1.15	1.16	3.86	3.88	3.39	3.76	3.83	3.38
III harvest	1.12	1.18	0.93	1.15	1.26	1.01	3.90	3.94	3.49	3.90	3.97	3.29
IV harvest	1.01	0.97	0.78	1.03	1.09	0.91	3.84	3.85	3.60	3.87	3.96	3.52
Mean	0.99	1.06	0.94	0.96	1.09	1.02	3.85	3.88	3.50	3.81	3.88	3.39
SE±	±0.07	±0.06	±0.06	±0.09	±0.08	±0.05	±0.02	±0.02	±0.04	±0.04	±0.05	±0.05
Spacing (20 cm)												
I harvest	0.75	0.92	1.01	0.77	0.84	0.90	3.55	3.60	3.50	3.59	3.61	3.32
II harvest	0.83	1.09	1.01	0.96	1.08	1.12	3.60	3.70	3.53	3.65	3.67	3.56
III harvest	0.89	1.08	0.89	1.12	1.18	0.97	3.68	3.79	3.34	3.80	3.89	3.46
IV harvest	0.82	1.02	0.77	0.98	0.99	0.79	3.65	3.75	3.51	3.82	3.78	3.39
Mean	0.82	1.03	0.92	0.96	1.02	0.94	3.62	3.71	3.47	3.71	3.74	3.43
SE±	±0.03	±0.04	±0.06	±0.07	±0.07	±0.07	±0.03	±0.04	±0.04	±0.06	±0.06	±0.05
Spacing (25 cm)												
I harvest	0.65	0.85	0.98	0.72	0.83	0.93	3.43	3.48	3.45	3.35	3.45	3.35
II harvest	0.73	1.07	0.99	0.90	1.05	1.09	3.52	3.61	3.52	3.46	3.52	3.50
IIIrd Harvest	0.89	1.12	0.87	1.07	1.06	0.94	3.59	3.70	3.32	3.36	3.48	3.45
IV harvest	0.77	0.99	0.76	0.89	0.97	0.82	3.60	3.51	3.48	3.52	3.59	3.44
Mean	0.76	1.01	0.90	0.89	0.98	0.94	3.53	3.57	3.44	3.42	3.51	3.43
SE±	±0.05	±0.06	±0.05	±0.07	±0.05	±0.05	±0.04	±0.05	±0.04	±0.04	±0.03	±0.03

Results

Pathology: Downy mildew infestation

Pathogen: *Peronospora farinosa* (Fr.) Fr. f. sp.*chenopodii*

Experiment

27 accessions of quinoa were assessed for degree of resistance and classified into disease reaction classes based on epidemiological parameters, i.e. severity index, AUDPC and rate.

Methods for quantification of disease epidemic based on AUDPC.

Model 1- AUDPC estimated over the entire season utilizing weekly severity data.

Model 2- AUDPC estimated on only two assessment dates, first at the start of epidemic and second at the peak severity stage of epidemic.

Results

- **4 accessions namely PI 510532, CHEN 67/78, Ames 22158 and CHEN 7/81 could be ideal source for the introgression of resistance genes in high yielding but downy mildew disease susceptible accessions through backcross breeding or molecular approaches.**
- **Method 2 was more suitable for quantification of disease epidemic in Indian conditions.**

Current state of quinoa in India

- **Rice and Wheat are staple food crops in India.**
- **For India: Quinoa is a cash crop that has wide nutritional ramifications.**
- **If India grows Quinoa at 1 percent of annual production area of rice and wheat, the yield will be 2 million tonnes.**
- **Economic value: could be about $10 billion (Rs 60,000 crore).**
- **India needs several million tonnes of quinoa a year to meet the requirement of its diabetics, cardiac patients and malnourished children.**
- **India has 130 agro-climatic zones and several of them can be suitable for quinoa.**

Current state of quinoa in India

Andhra Pradesh

PROJECT ANANTHA

- **Ananthapuramu district- Drought affected.**
- **Quinoa: good alternative to the groundnut crop which has become unsustainable due to decreasing rainfall.**
- **Quinoa was grown both at Hyderabad and in Ananthapuramu district.**
- **Experiments resulted in emergence of an Indian specific variety which is known as 'Project Anantha Quinoa'.**
- **The crop has been successfully harvested by a farmer in Ananthapuramu district and being successfully grown by 47 other farmers.**
- **A quinoa processing facility is being developed in Anantapur which provide for manufacturing of value added products.**

Current state of quinoa in India

Uttar Pradesh

- **Bundelkhand region- Severely drought prone.**
- **Last few years:**
  Normal rainy days: Reduced from 52 to 24 days annually.
  Rainfall: Reduced from 800-900 mm to 400–450 mm annually.
  Food grain production: Reduced from 15 % to 7%.
  Wheat production: 2012-13- 23.87 quintals per hectare
  2014-5- 11.28 quintals per hectare
- **Around 18 lakh people have migrated from Bundelkhand over the years.**
- **Since 2003, 3,500 farmers are estimated to have committed suicide in the region.**

- **In 2015, Organic Wellness Products Ltd distributed seeds of the crop to over 500 farmers of Bundelkhand villages.**
- **Sowing: November; Harvesting: March.**
- **Goal: 1500 MT of Quinoa in 2015-16 and aim of 5000 MT in 2016-17.**

Current state of quinoa in India

Rajasthan

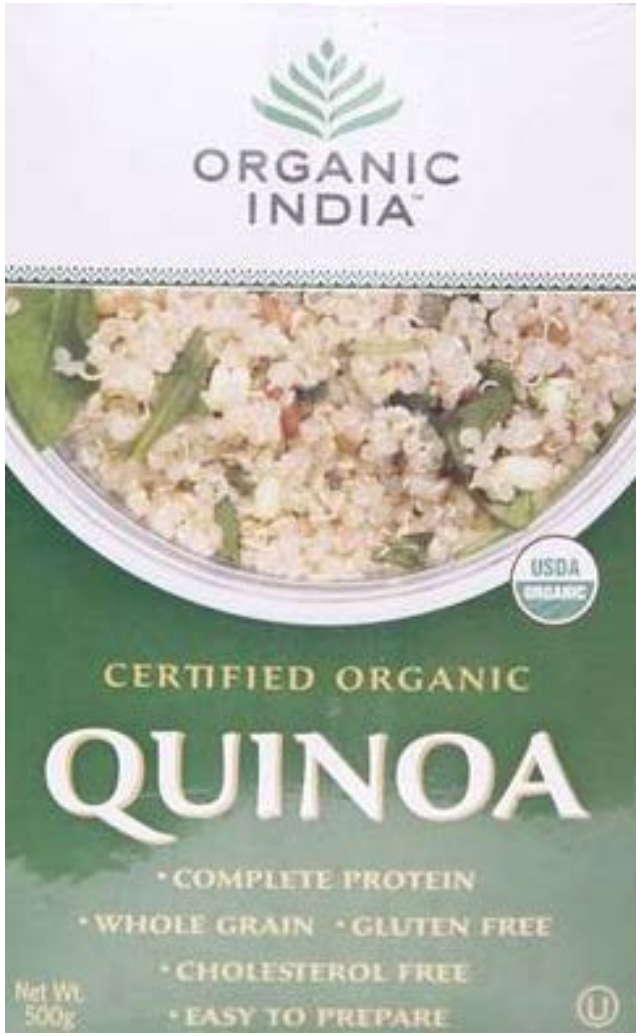
- **Private entrepneurs: First planted quinoa on outskirts of Jaipur, later in Jaisalmer and Pokhran.**
- **The state will start cultivation of quinoa with Government initiatives.**
- **Bhilwara and Chittorgarh districts have been identified.**
- **Government aims to increase the farmer's income by more than 20% by cultivating quinoa.**
- **Buyback guarantee scheme for quinoa in cooperation with export companies.**

Uttarakhand

2013: Uttarakhand government signed a horticulture research agreement with Peru to grow quinoa in the state.

Maharashtra; Himachal Pradesh, Jammu and Kashmir (Laddakh region)

Quinoa in India



Rs. 599/500 g

Rs. 299/500 g

Future Directions

(i) Invoking the interest of farmers: Disseminating information to producers regarding the benefits of the crop in terms of income generation and nutritional security.

(ii) Educating farmers: regarding cultivation, cultural practices, agronomy and pathology of the crop.

(iii) Seed availability: free or subsidized high-quality seeds.

(iv) Building a suitable marketing infrastructure.

(v) Initiation of participatory research: most importantly crop stability and selection of genotypes suited to different agroclimatic conditions.

Indian model of quinoa development

Cultivation

- **Should be favoured initially for marginal lands.**

Consumption

- **As a supplement in wheat flour for general population, especially the protein undernourished.**
- **Mid Day Meal Scheme.**

SOCIAL OBJECTIVE

THANK YOU

OUR TEAM