

Improving drought tolerance in chickpea for Africa and Asia



Project Delivery Coordinator: **Pooran Gaur**

Principal Scientist (Chickpea Breeding)
ICRISAT, Patancheru, India

Target countries: as in **Tropical Legumes I**

Africa : Kenya, Ethiopia and Tanzania

Asia : India

Proposed Activities

- 1. Development of genetic and genomic resources**
- 2. Exploring and utilizing the functional allelic diversity**
- 3. Precise phenotyping for drought tolerance traits**
- 4. Identification of markers associated with QTLs for drought tolerance traits**
- 5. Marker-assisted introgression of drought tolerance traits in farmer-preferred cultivars**
- 6. Marker-assisted recurrent selection (MARS) for cumulating favorable alleles for drought tolerance**

Activity 1: Development of genetic and genomic resources

Outputs:

- At least 1000 MAGIC lines developed
- Solexa sequencing datasets (1 GB per genotype) available for 16 genotypes for gene expression analysis and marker discovery
- GoldenGate assay available for genotyping 1536-9216 SNPs
- A high density genome map of chickpea consisting of over 2000 markers available

Projects: TL-I, GCP-CG: Chickpea SNP resource

Development of MAGIC populations

Two 8-parent MAGIC populations one each in desi and kabuli type involving cultivars/elite lines from Africa and Asia and drought tolerant parents of RILs

Crossing scheme: Reduced crossing scheme borrowed from partially balanced lattice design of field trials
- Ian Mackay

28 two-way, 14 four-way and 7 eight-way crosses

[(12) x (34)] x [(56) x (78)]

[(17) x (28)] x [(35) x (46)]

[(16) x (38)] x [(25) x (47)]

[(14) x (67)] x [(23) x (58)]

[(15) x (26)] x [(37) x (48)]

[(13) x (57)] x [(24) x (68)]

[(18) x (45)] x [(27) x (36)]

Updates on Activity 1 (Continued....)

- **Solexa sequence data (38 million reads) already generated for ICC 4958 and ICC 1882 (*see Poster 4.14*)**
- **Illumina GoldenGate assay for 768 SNPs developed (in collab. with Doug Cook, UC-Davis) (*see Poster 2.15*)**
- **High density genome map: An integrated genome map map of over 1000 markers developed using *C. arietinum* x *C. reticulatum* RILs (*see Poster 2.11*)**

Activity 2: Exploring and utilizing the functional allelic diversity

Outputs

- Allelic diversity data for 1536-9216 SNP available on the reference/ composite/ global collection of chickpea
- Marker/gene-trait association based on LD available

Projects: TL-I, GCP-CG: Chickpea SNP resource

Activity 3: Precise phenotyping for drought tolerance traits

Outputs

- Precise phenotyping data available for root traits and $\delta^{13}\text{C}$ on reference collection, recombinant inbred and MAGIC lines
- Multilocation phenotyping data available on mapping populations, reference collection and MAGIC lines for grain and biological yield

Projects: TL-I, GCP-CG: Association mapping-reference collection, GCP-CG: Linkage mapping-RILs

$$\text{Grain Yield (under drought)} = T \times TE \times HI$$

Passioura (1977)

Reference collection: data collected for $\delta^{13}\text{C}$, SLA and SCMR (see Poster # 3.16)

RILs: Evaluation of ICC 4958 x ICC 1882 RILs for HI, grain yield and $\delta^{13}\text{C}$ at 4 locations during 2008/09

Correlation of grain yield with biomass, HI and $\delta^{13}\text{C}$

	Nandyal	Patancheru	Sehore	Durgapura
Biomass yield	0.98**	0.84**	0.96**	0.76**
Harvest Index	0.82**	0.41**	0.22**	0.97**
$\delta^{13}\text{C}$	-	0.23**	0.10	0.17**

Activity 4: Identification of markers associated with QTLs for drought tolerance traits

Outputs

- **Gene based markers identified associated with at least 10 QTLs for root traits, TE and HI**
- **Most promising 5 QTLs selected for breeding applications**

Projects: TL-I, GCP-CG: Association mapping-reference collection, GCP-CG: Linkage mapping-RILs

Activity 5: Marker-assisted introgression of drought tolerance traits in farmer-preferred cultivars

Outputs

- **At least 5 drought tolerance QTLs introgressed in 6 farmers preferred varieties each from South Asia and Sub-Saharan Africa**
- **MABC introgressed lines evaluated under drought conditions in targeted environments**

Projects: TL-1

Crosses: 3 Cultivars x 2 Donors for root traits

BC1: Cultivar x F1
↓
BC1F1

BC 2: Cultivar x BC1F1
↓
BC2F1

Subjected to foreground and background selection

BC3: Cultivar x BC2F1
As in BC 2

Selected heterozygous plants for QTL-linked markers
and over 90% genome of the recurrent parent

↓
BC3F1
↓
BC3F2

Select homozygous plants for QTL-linked markers

↓
BC3F3

Seed multiplication



Multilocation evaluation BC3F4 lines

Donors



Cultivars



Activity 6: Marker-assisted recurrent selection (MARS) for cumulating favorable alleles for drought tolerance

Outputs

- **Selection index constructed for selection of plants for intercrossing based on phenotypic and molecular markers data**
- **Breeding lines cumulating as many favorable alleles as possible for drought tolerance developed through MARS.**

Projects: TL-1

MARS for improving drought tolerance

Five good-by-good crosses involving cultivars from Africa and Asia

Set 1 (2 crosses)

Set-2 (3 crosses)

2008/09

Genotyping of F3 plants

F2 gown

F4 (Seed mutiplication)

Genotyping of F3 plants

Multilocation evaluation
of F5 progenies and
QTL analysis

F4 (Seed mutiplication)

Selection and inter-crossing
of F3s

Multilocation evaluation
of F5 progenies and
QTL analysis



Partners in Chickpea CI

- **ICRISAT- Patancheru, India** (Pooran Gaur, Rajeev Varshney, L Krisnamurthy, Vincent Vadez, Hari Upadhyaya, S Tripathi)
- **Nairobi, Kenya** (NVPR Ganga Rao, Said Silim)
- **Egerton University, Kenya:** (Paul Kimurto)
- **EIAR, Ethiopia** (Million Eshete)
- **LZARDI, Tanzania** (Robert Kileo)
- **UAS-Bangalore, India** (KP Vishwanatha, MS Sheshashaye)
- **ANGRAU-Hyderabad, India** (Veera Jayalakshmi)
- **IIPR-Kanpur, India** (SK Chaturvedi, Aditya Garg)
- **RSKVV-Gwalior, India** (M Yasin)
- **RAU-Bikaner, India** (SJ Singh)
- **UC-Davis, USA** (Doug Cook)
- **University of Frankfurt, Germany** (Peter Winter, Guenter Kahl)
- **JIRCAS, Japan** (Satoshi Tobita, Osamu Ito)
- **DArT P/L** (Andrzej Killian)



Thank You