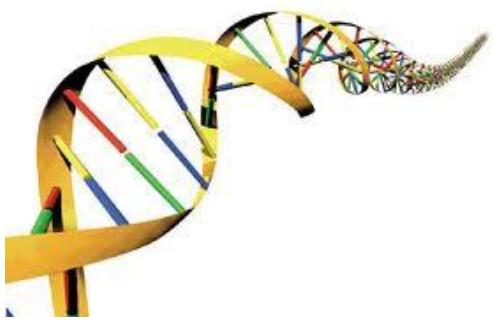
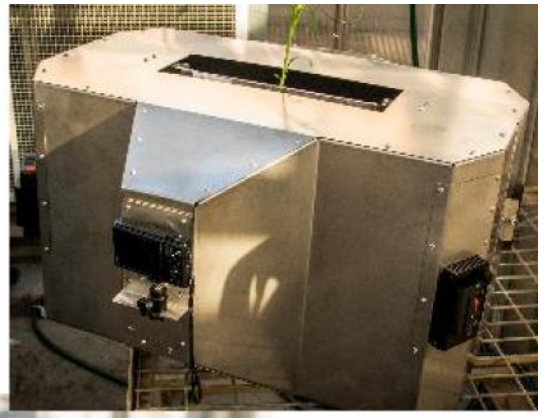
High-throughput phenotyping platform for nodal root angle in sorghum



Vijaya Singh, Erik van Oosterom, David Jordan, Emma Mace, Dinesh Joshi, Graeme Hammer



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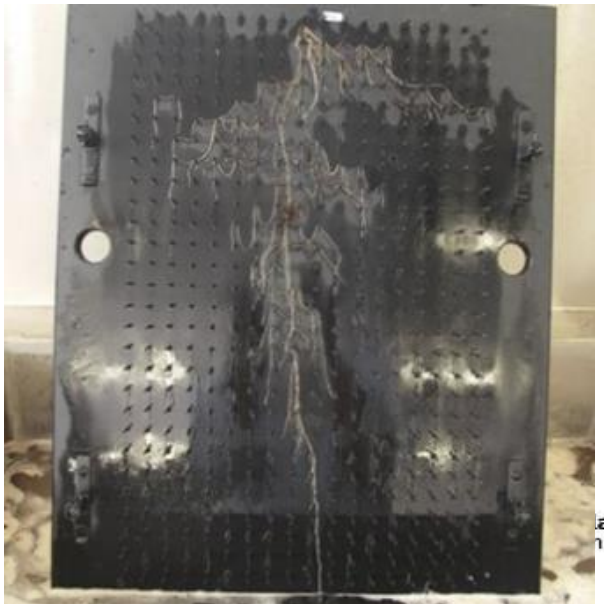
Aims

- **Understand growth and development of sorghum root systems**
- **Identify key root traits determining genetic variation in root systems architecture at seedling stage**
- **Influence of differences in root system at seedling stage on spatial root distribution and water capture of mature plant**
- **Identify genomic regions associated with nodal root angle**
- **Develoment of high-throughput phenotyping platform to identify QTL/genes influencing nodal root angle**

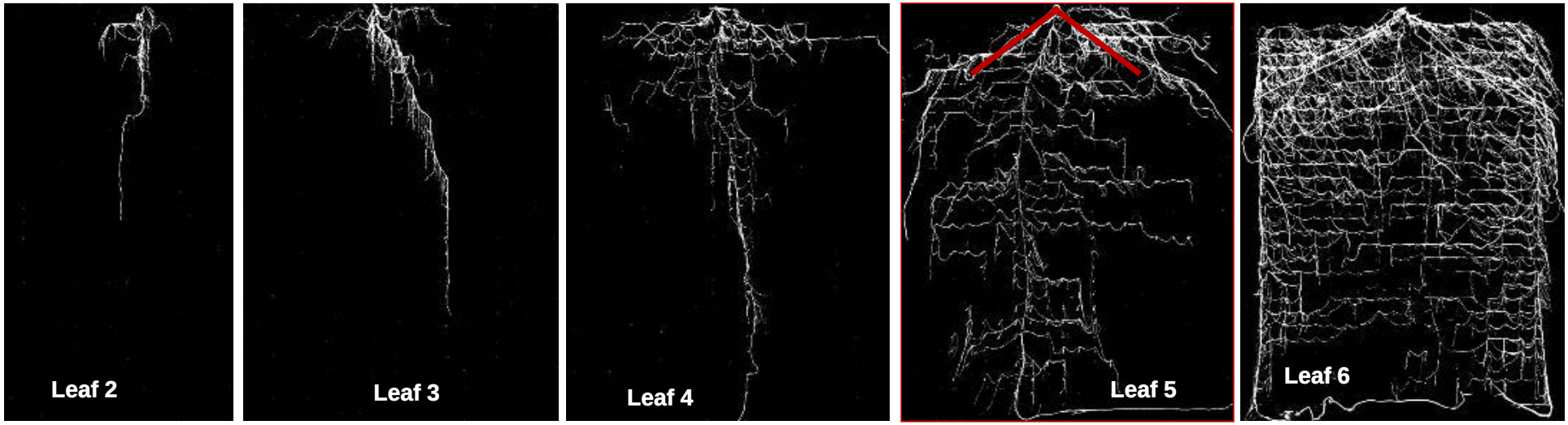
Growth and development of sorghum root systems at seedling stage

- Soil filled chambers (Rhizotron)
- 40 cm wide, 60 cm deep and 5 cm thick
- 4 genotypes, 3 replications
- 5 harvests (leaf 2-6 leaf stage)
- Roots washed on pinboard



Growth and development of root systems at seedling stage

Singh et al. 2010, plant and soil 333: 287-299



- Sorghum produces only one seminal root
- Nodal root starts to appear at 5-6 leaf stage
- Genotypic difference in nodal root angle
- Critical stage for nodal root angle screening leaf 5-6
- Phenotyping requires chambers of 50cm x 45cm

Influence of differences in root at seedling stage on spatial root distribution of mature plant

- Rhizotron 120cm wide x120 cm deep x10cm (leaf 6 to 16)
- Rhizotron 120cm wide x240cm deep x10cm (flag leaf-midgrain filling)
- Contrasting lines differing in nodal root angle but had similar phenology and tillering
- Roots washed on pinboard
- Contrasting lines differed in root distribution pattern

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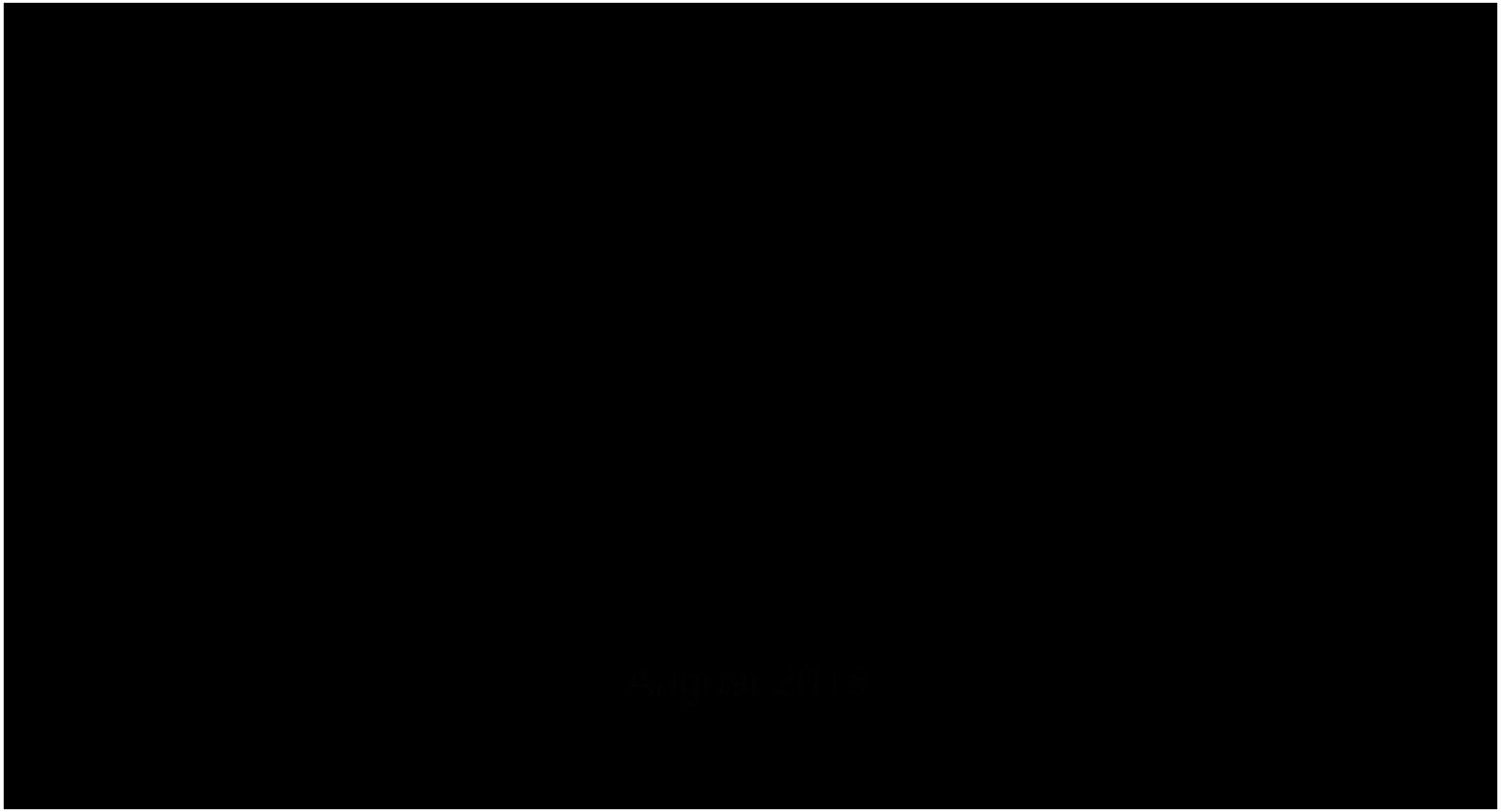
Influence of differences of root at seedling stage on spatial root distribution of mature plant (leaf 6-16)

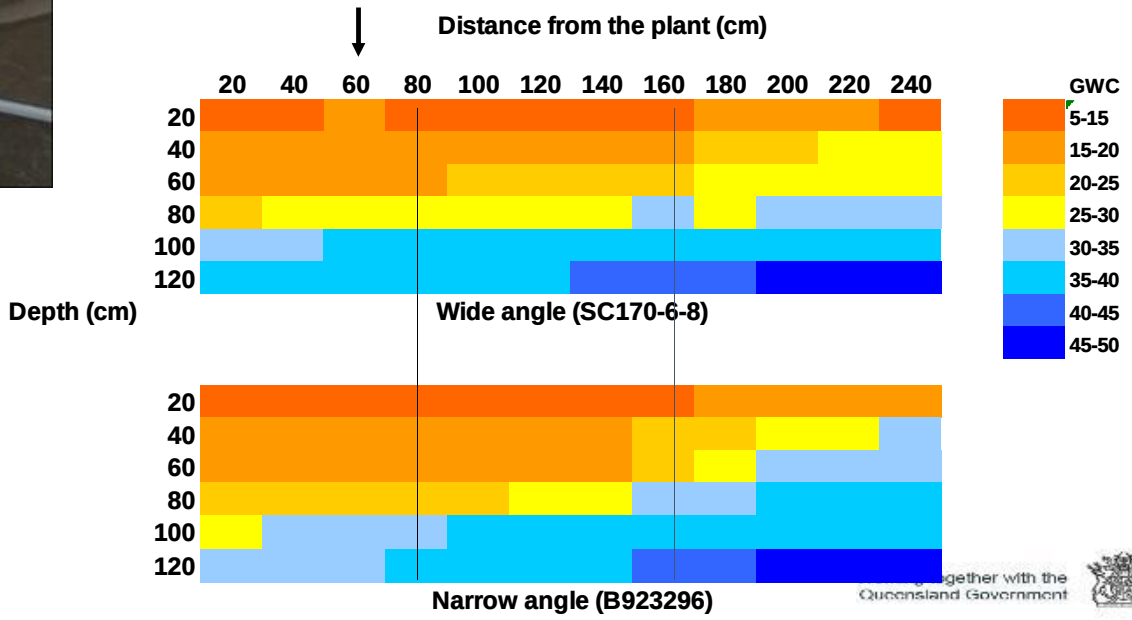


Influence of differences in root at seedling stage on spatial root distribution of mature plant (flag leaf-mid grain)

Influence of differences in root at seedling stage on water capture of mature plant

Singh et al. 2012. Europ. J. Agronomy. 42:3-10

- Rhizotron 120x240x10cm
- 4 Inbred lines with contrasting root angles
- Planted at 60 cm from one side
- GWC measured at anthesis from 20x20cm grids



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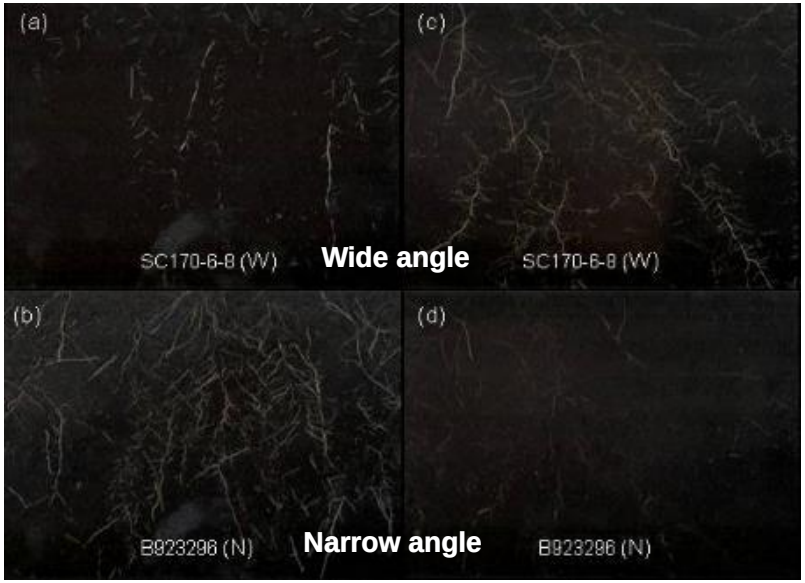
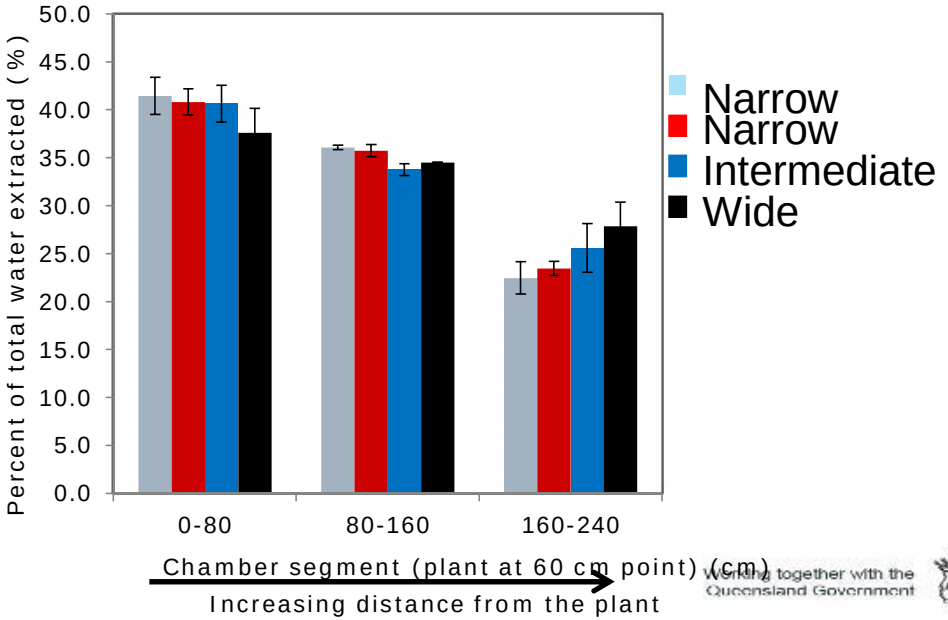
Influence of differences in root at seedling stage on water capture of mature plant

Singh et al. 2012. Europ. J. Agronomy. 42:3-10



Below the plant **Distant to the plant**

- **Narrow angle line; more roots below the plant and less roots away from the plant**
- **Narrow angle line; extracted more water below the plant line**
- **Narrow angle line; extracted less water away from the plant line**



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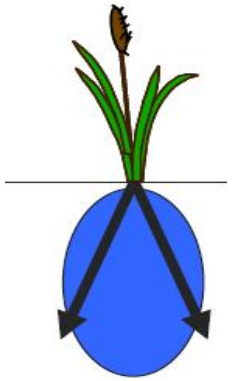
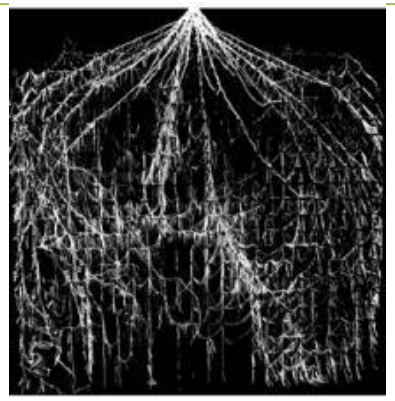
Influence of differences in root at seedling stage on water capture of mature plant

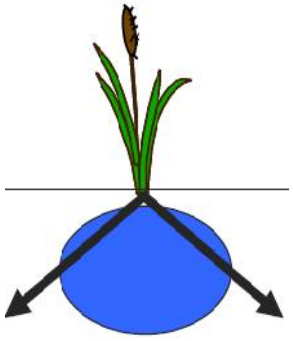


Narrow root angle



Deep roots

Drought environments



Wide root angle

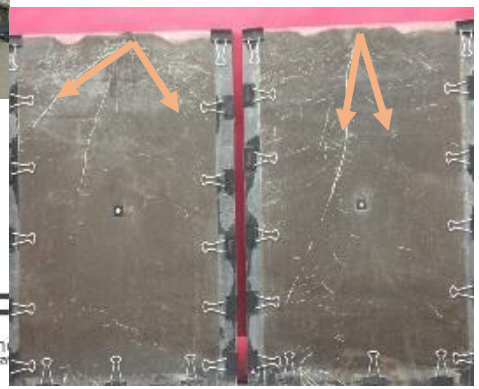
Shallow roots

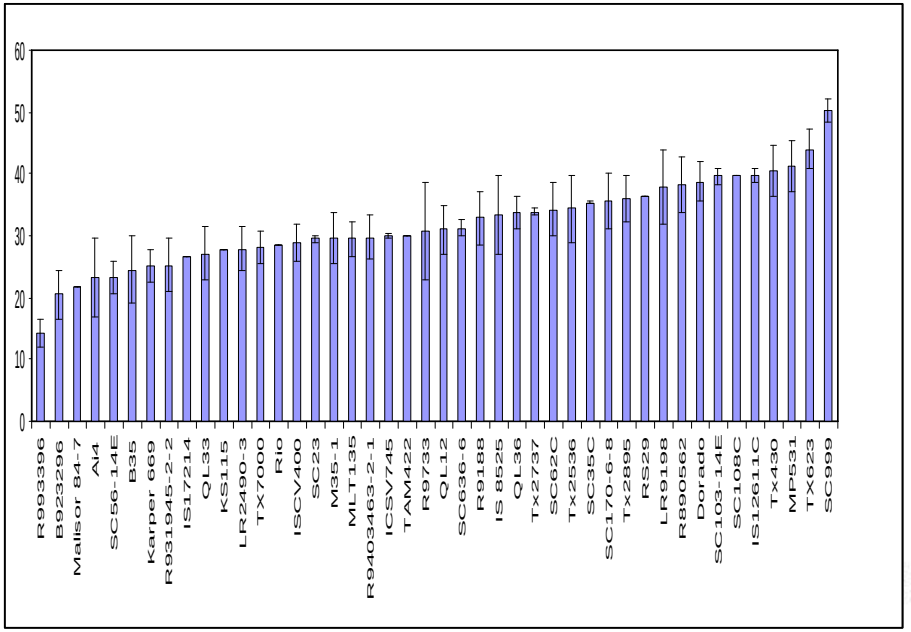
Skip row management system

Genetic variation for nodal root angle

Singh et al. 2011. Crop Science. 51:2011-2020

- Soil filled chambers used for screening
- 74 hybrids and inbred lines screened
- Plants harvested at 6 leaf stage
- High genetic variation in nodal root angle (15-50°)
- High heritability
- Ample scope for variety improvement through breeding





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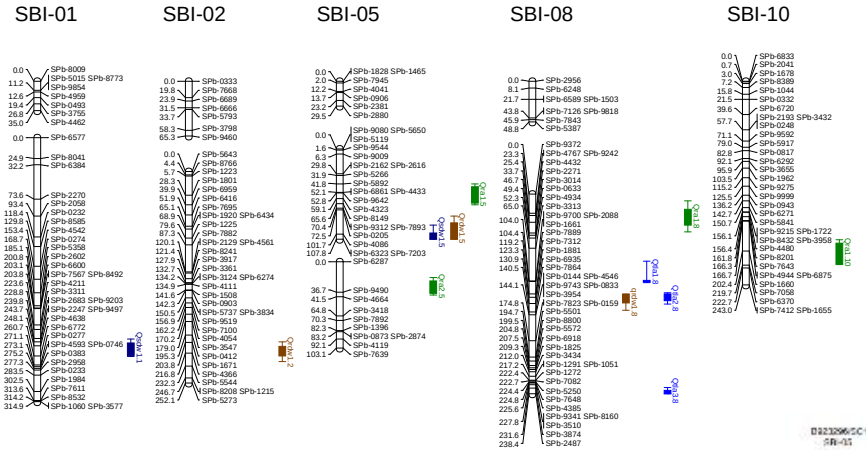
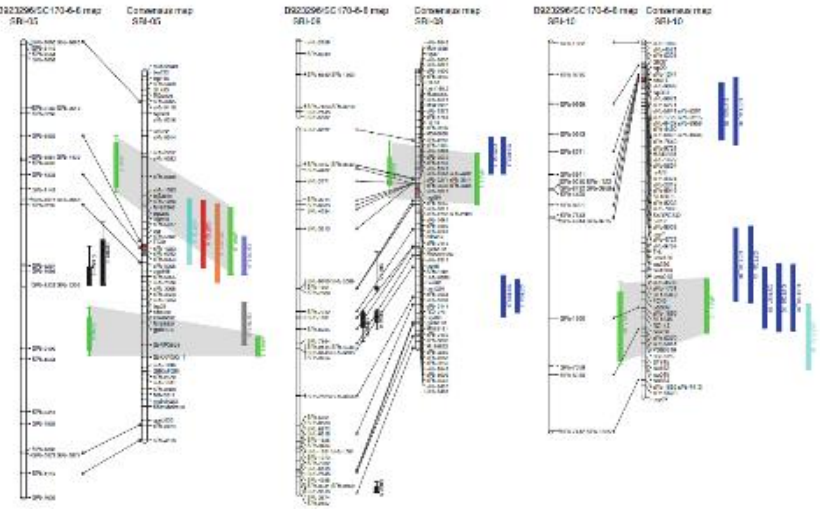
Genomic regions associated with nodal root angle

Mace et al . 2012. Theor Appl Gen, 124:97-109



- nodal root angle - green
- root dry weight - brown
- shoot dry weight - dark blue
- total leaf area - light blue

- **Total 213 RIL**
- **Four QTL governing nodal root angle were identified in a biparental mapping population**
- **Explained 58.2% of phenotypic variation**
- **Root angle QTLs co-located with previously identified QTLs for stay green**
- **Strong association between nodal root angle QTLs and grain yield data from field trials**
- **Increase in yield in the presence of narrow root angle QTLs**



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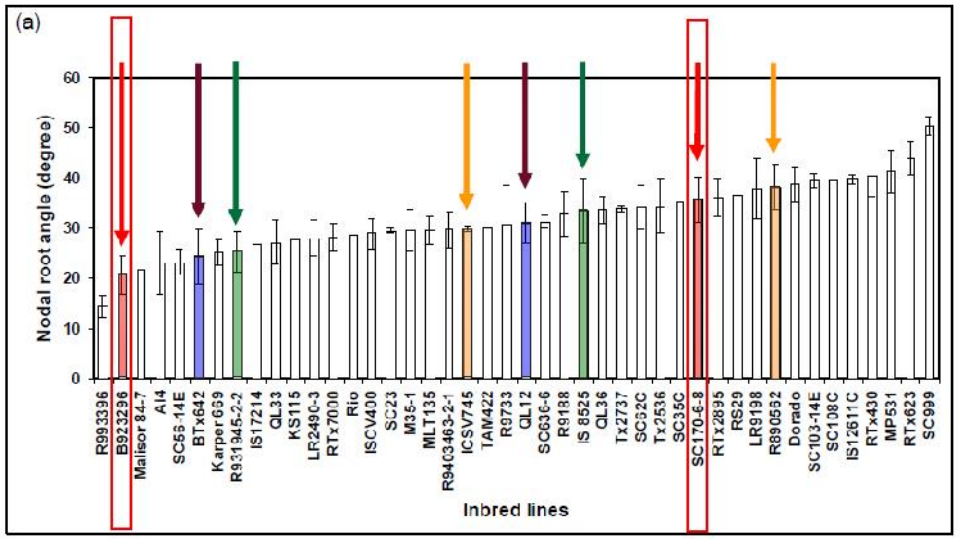
Nested Association Mapping (NAM) resource for dissecting the RSA in sorghum

Jordan et al, 2011, Crop science 51:1444-1457

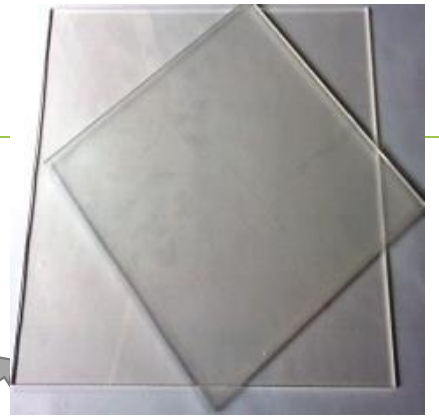
- **Excellent resource for elucidating the genetic control of complex traits viz., RSA**
- **High genetic variation in nodal root angle has been observed for NAM parents**
- **A multi allelic resource for identifying the genomic regions governing nodal root angle**



Singh *et al*, 2011, Crop Science 51:2011–2020

High-throughput phenotyping platform

- Each chamber is made of two transparent Perspex sheet
- Perspex sheet separated by 3mm thick rubber
- Two Perspex sheet held together by steel clamps
- Soil filled chambers 50cm high, 45cm wide and 3mm thick
- Each chamber is filled with approximately 900 gm soil



Transparent Perspex sheet

Rubber

Old chambers

New chambers

Clamp

High-throughput phenotyping platform

Chamber

Steel tub

Polycarbonate covers

Tub with chambers and barcodes

- The chambers are kept in 2m long steel tub
- Each tub has slot at top and bottom to hold the chambers
- Each tub can hold 50 chambers
- Polycarbonate covers to avoid light
- 10 tubs in total
- Screen 500 plants per run

Plants at 5 leaf stage

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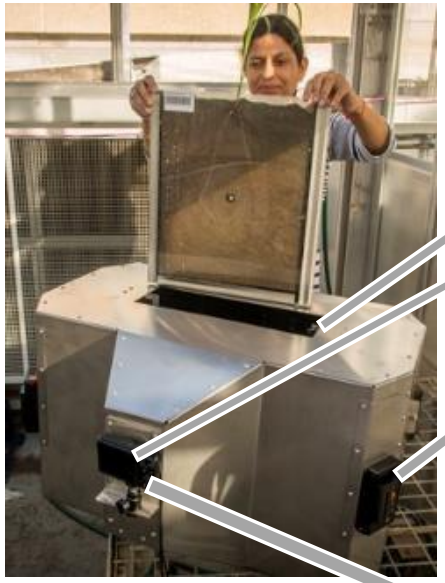
High-throughput imaging box



Imaging box with cameras and lights

- Imaging box for easy imaging of roots
- Two cameras operated by tablets through inbuilt Wi-Fi
- Four lights with filters
- Barcoding maintains the identity of genotype
- Root angle average of four observations

MR. Lefty

MR. Righty

Conclusions

- **The phenotyping platform provides high throughput, low cost easy to screen for phenotypic variation in nodal root angle in sorghum**
- **Phenotypic platform is highly effective to screen large NAM populations for nodal root angle**
- **Presence of genotypic variation in nodal root angle with high heritability and under strong genetic control**
- **Rapid phenotyping opens opportunity for detection of nodal root angle QTL/genes for molecular breeding**
- **Contrasting lines differ in spatial root development patterns and hence in spatial water extraction patterns of mature plants**
- **Narrow root angle is associated with drought adaptation**

Acknowledgements

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Your GRDC working with you

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