MORPHO-PHYSIOLOGICAL ROOT TRAITS LINKED TO DROUGHT TOLERANCE IN CHICKPEA

(*Cicer arietinum* L.)

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Chickpea role in cropping system

• Major legumes grown in Kenya
  – Common beans, pigeon peas, groundnuts, chickpeas, green grams

• Chickpeas are traditionally grown in Semi-arid areas in Eastern parts of Kenya in small area

• Currently chickpea as legume is gaining importance due to
  – Its introduction into mid-highlands as rotational cereal-legume after wheat-maize during short rains-incomes and protein
  – Improving soil fertility and reduction of cereal diseases (Maize Lethal Necrosis Diseases-MLND)
  – Rising demand fresh produce exporters -Kabuli types
  – Increasing drought stress due to climate change-affecting beans

–Kenya annual production-18-20,000 tons from 45,000 hectare-Eastern, Rift valley mainly
Introduction

- Major abiotic stress affecting production is drought
- Kenya’s land is 80% arid to semi-arid (ASAL)
- Rainfall is low and unpredictable – climate change
- Chickpea is more resilient in ASALs
Seed attributes preferred by farmers (already released)

Kabuli-ICCV 92318
Large seed, Cream canning, cooked as vegetable salad

Desi-ICCV 97105
Dark-Brown seeded Cooked with maize, potatoes
Introduction

• Several efforts in breeding and introduction of drought tolerant varieties)
  – Early maturing varieties - Escape drought eg ICCV 10, and 6 widely adapted varieties
• Grown during short rain season, experiences terminal drought stress from podding to grain filling is major stress (Oct-Feb)

• Well established root system recognized the most important traits for enhancing drought, due to enhanced water acquisition (Kashiwagi et al., 2006, 2015; Varshney et al., 2014)
• Identifying genotypes with improved root and physiological traits could have a significant impact on yield productivity under drought stress
Objectives

• Characterize the root traits that could be linked to drought tolerance in diverse chickpea germplasm

• Evaluate yield performance in drought stress conditions to assess drought tolerance
Methodology

• 10 genotypes of diverse characteristics evaluated

• Commercial released varieties
  – Chania desi 1-ICCV 97105, Chania 2- ICCV 92944 and LTD 068-ICCV 00108,

• Elite advanced lines
  – ICCV 97306, ICCV 92318

• Susceptible lines -ICC 283, Ngara local

• Tolerant checks ICC 4958, ICC 1882, ICC 3325
Methodology

- Genotypes, sown in 20 cm diameter, 120 cm tall Polyvinyl chloride (PVC) cylinder under a rainout shelter (Kashiwagi et al., 2005)

- Pipes filled soil: sand mixture in a 1:1 ratio, then filled with water up to 70% field capacity, in a Laid in an alpha design

- PVC Pipes under rain out shelter, Egerton University
Methodology

• The sand was mixed to balance the bulk density and to reduce the water holding capacity.

• The cylinders were placed in 1.2 m deep cement pits under rain shelter to avoid the incidence of direct solar radiation on the cylinders.
Methodology

- Plants were harvested at 40 DAS
- Roots washed from the cylinders gently with the help of running water.
- The root system then separated into 30 cm sections (0-30 cm, 30-60 cm, 60-90 cm, 90-120 cm), to measure the root length at each of the 30 cm depth, using an image analysis system (WinRhizo, Regent Instruments INC., Canada)
Washing trays

WinRhizo Root analysis system
Methodology

Data collected:

• Root and shoot dry weights (Biomass)
• Total root length (cm)

• Root length density (RLD) was obtained by dividing the root length by soil volume of the cylinder
  \[ \text{RLD (cm/cm}^3\text{)} = \frac{\text{Length of roots (cm)}}{\text{Volume of soil core (cm}^3\text{)}} \]

• Total plant dry weight (root + shoot dry weights)
• Ratio of root dry weight to shoot dry weight (R:S)
Evaluation under simulated drought stress under rain shelter
Methodology

- Field evaluation was done in Baringo County (Marigat station), Design in RCBD, 3 reps
Results and Discussion

Mean Root biomass

- ICC 4958
- ICC 1882
- ICCV 00108
- ICC 283
- Ngara Local
- ICCV 97105
- ICC 3325
- ICCV 92944
- ICCV 97306
- ICCV 92318
- ICCV 97306

Mean Root biomass
Results and Discussion

Shoot Biomass (gms/plant)

- ICC 4958
- ICC 1882
- ICCV 00108
- ICC 283
- Ngara Local
- ICCV 97105
- ICC 3325
- ICCV 92944
- ICCV 92318
- ICCV 97306

Biomass (gms/plant)
Results

Shoot and root characteristics of evaluated genotypes
Results and Discussion

Mean Root:shoot ratio

- ICCV 97306
- ICCV 92318
- ICCV 92944
- ICC 3325
- ICCV 97105
- Ngara Local
- ICC 283
- ICCV 00108
- ICC 1882
- ICC 4958

Mean Root:shoot ratio
Total Root length density (cm cm⁻³)

- ICC 4958: High RLD
- ICC 1882: Moderate RLD
- ICCV 00108: High RLD
- ICC 283: Moderate RLD
- Ngara Local: Low RLD
- ICCV 97105: Moderate RLD
- ICC 3325: High RLD
- ICCV 92944: High RLD
- ICCV 92318: Moderate RLD
- ICCV 97306: High RLD

0-30cm had high RLD, followed by 30-60cm and >60cm profile.
Results

Total root Length (cm)

- ICCV 97306
- ICCV 92318
- ICCV 92944
- ICC 3325
- ICCV 97105
- Ngara Local
- ICC 283
- ICCV 00108
- ICC 1882
- ICC 4958
## Yield and Seed weight-field evaluation

<table>
<thead>
<tr>
<th>Variety</th>
<th>100 seed weight (g)</th>
<th>Yield (Kgs/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICCV 92318</td>
<td>22.84</td>
<td>650.5</td>
</tr>
<tr>
<td>ICCV 97306</td>
<td>19.24</td>
<td>629.6</td>
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<tr>
<td>ICC 4958</td>
<td>17.71</td>
<td>638.4</td>
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<tr>
<td>ICCV 92944</td>
<td>16.09</td>
<td>796.0</td>
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<td>ICCV 00108</td>
<td>15.72</td>
<td>674.7</td>
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<td>Ngara local</td>
<td>12.53</td>
<td>493.0</td>
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<td>ICC 283</td>
<td>11.41</td>
<td>398.4</td>
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<tr>
<td>ICCV 97105</td>
<td>16.73</td>
<td>540.7</td>
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<tr>
<td>ICC 3325</td>
<td>10.96</td>
<td>417.3</td>
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<tr>
<td>ICC 1882</td>
<td>14.79</td>
<td>455.0</td>
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</tbody>
</table>
# Results of Root characteristics of MABC lines

**Poster no 90**

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Root biomass (gms)</th>
<th>Root length density (cm/cm^3)</th>
<th>Total Root length (cm)</th>
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</thead>
<tbody>
<tr>
<td>EU41</td>
<td>0.89</td>
<td>0.171</td>
<td>1560</td>
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<tr>
<td>EU45</td>
<td>0.36</td>
<td>0.037</td>
<td>978</td>
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<td>EU2</td>
<td>0.36</td>
<td>0.052</td>
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<td>EU3</td>
<td>0.34</td>
<td>0.034</td>
<td>905</td>
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<td>ICCV92944</td>
<td>0.43</td>
<td>0.044</td>
<td>890</td>
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<tr>
<td>EU42</td>
<td>0.79</td>
<td>0.097</td>
<td>1183</td>
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<tr>
<td>EU44</td>
<td>0.68</td>
<td>0.093</td>
<td>1236</td>
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<tr>
<td>EU4</td>
<td>0.27</td>
<td>0.038</td>
<td>799</td>
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<tr>
<td>ICC4958</td>
<td>0.54</td>
<td>0.065</td>
<td>1033</td>
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<tr>
<td>Mean</td>
<td>0.52</td>
<td>0.07</td>
<td>1105.6</td>
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<tr>
<td>C.V.%</td>
<td>2.4</td>
<td>11.2</td>
<td>11.2</td>
</tr>
</tbody>
</table>
Results of Root characteristics of MABC lines

Poster no 90

Yield gms/plot  Biomass gms/plot

EU41  ICCV 92944  ICC4958  EU46  EU45  EU48  EU49  EU42  EU44
Conclusion

- Root traits linked to drought tolerance were demonstrated: Genotypes which had high RLD, root biomass, and total length (ICC 4958, ICCV 92944, ICCV 92318) did better under field condition.

- System increased efficiency of analyzing root traits under drought stress—many samples can be measured/day with high accuracy of WinRhizo Software (compared to Pin box technique, transect).

- Need to undertake multi-location evaluation to identify other morphophysiological traits involved in drought tolerance to be used with root trait.
Acknowledgment


Vadez V, Gangarao R.K, Siambi M, Gaur P. and Varshney R
THANK YOU