Morpho-physiological characteristics and grain yield attributes of selected cowpea genotypes under phosphorus and moisture stress conditions on a South Africa Typic Ustipsamment

Thosago SS[1], FR Kutu[2*] IK Mariga[1] & AB Olaniyan[3]

[1]Department of Plant Production, Soil Science and Agricultural Engineering ,University of Limpopo (Turfloop Campus), P/Bag X1107, Sovenga 0727, South Africa; [2]Department of Crop Science, School of Agricultural Sciences, Faculty of Natural and Agricultural Sciences, North-West University Mafikeng Campus, P/Bag X2046, Mmabatho 2735, South Africa; [3]Department of Agronomy, University of Ibadan, Nigeria.

E-mail: Funso.Kutu@nwu.ac.za, Tel: +27 18 389 2742

Introduction

Cowpea (*Vigna unguiculata* (L) Walp) production in South Africa is currently at subsistence level with limited commercial production solely for fodder. Its productivity as pulses is however, constrained by drought and widespread phosphorus (P) deficiency problems. An agronomic field trial was planted at during 2012/13-summer growing season to assess the response of 8 selected genotypes to low soil P and moisture stress conditions so as to identify potential genotype that adapt well to South African field conditions.

Materials and Methods

- **Description of trial site:** Ukulima Farm (24°32'58.1" S, 28°06'21.1" E, 1237 masl) in Limpopo Province, South Africa; rainfall amount less than 400 mm annually; Soil is loamy sand, low in phosphorus and classified as Typic Ustipsamment.
- **Treatments and trial lay out:**
  - Treatments: 2 soil P levels (low and high), 2 moisture status (water stress and well-watered); and 8 cowpea genotypes (Tvu 4632, Tvu 6365, Tvu 9848, Tvu 15445, Tvu 16408, Tvu 15143, Oloyin and IT00K-1217).
  - Low soil-P level implies *in situ* available P<8 mg kg^{-1} while high P level was 40 kg P ha^{-1} application rate.
  - Treatments laid out as split plot arrangement, fitted into RCBD and each replicated 4 times.
  - Each subplot measured 9 m × 10 m; cowpea seeds sown at 90 & 20 cm inter and intra-row spacing, respectively; P fertilizer applied as SSP (10.5% P).
- **Data collection:** (i) growth parameters-plant height, number of branches, number of trifoliate leaves, stem diameter using vernier calliper; cowpea root architecture-stem and taproot diameter at different depths, number of basal root and root angle essential for optimizing water-use and P-use efficiency) during reproductive stage using legume phenotypic shovelomic scoreboard and root scanner (Fig 1), and (ii) grain yield at harvest.
- **Data analysis:** ANOVA was performed on plant growth, root and grain yield data generated using Statistix 10.0; treatment means separated at 5% probability level.

Fig 1: Soil core sampling for root distribution assessment, phenotyping and scanning

Fig 2: Root architecture as affected by variation in soil P and water conditions

Conclusions

Elevated level of soil available P mitigated the negative effect of moisture stress through enhanced root growth and development. Tvu 15143 withstand better moisture stress than any other genotypes while Tvu 16408 gave the highest grain yield. However, Oloyin was the least performer under these abiotic stress conditions

Results and Discussions

- There was significant (P≤0.05) variation in plant height, number of branches, number of trifoliate leaves per plant and grain yield under the two P rates among the cowpea genotypes (Table 1). Grain yield was not negatively affected by low soil P condition but decreased significantly by moisture stress condition
- Among the morpho-physiological traits, stem diameter, tap root diameter up to 15 cm and basal roots had significantly positive but weak (r<0.250) correlation with grain yield (Table 2)
- Noticeable variation in root architecture and distribution across soil depth attributed to differences in soil P availability and moisture condition (Fig 2) with significant P rates × moisture interaction effects on the mean number of trifoliate leaves, lateral root density and grain yield

Table 1: Effect of cowpea genotype on moisture stress condition and phosphorus levels on cowpea growth parameters and grain yield

Treatments	Plant height at 6 WAP	Plant height 8 WAP	No branches at 6 WAP	No branches at 8 WAP	No trifoliate leaves at 6 WAP	No trifoliate leaves at 8 WAP	Grain yield (kg ha^{-1})
Soil P level							
Low	11.9b	16.9b	3.6b	4.6a	5.6b	12.1b	1710a
High	15.3a	22.7a	4.3a	5.9a	8.1a	16.6a	1963a
Moisture status							
Well-watered	14.3a	21.1a	3.1a	4.1a	7.0a	14.4a	2059a
Water stressed	12.9a	18.6a	3.9a	4.8a	6.8a	14.3a	1614b
Cowpea genotypes							
IT00K-1217	10.4b	14.5de	3.4b	4.3bc	4.6c	9.7c	1256b
Oloyin	11.1b	14.4e	3.2b	4.2c	5.8bc	13.8b	1441b
Tvu 9848	13.8ab	20.1bc	4.4a	5.2a	6.5b	14.4b	1960ab
Tvu 6365	12.8ab	18.6cd	4.1ab	5.1ab	7.4b	15.4ab	1810ab
Tvu 4632	13.6ab	21.2abc	3.6ab	4.8abc	6.3b	13.0b	1732ab
Tvu 15445	18.4a	21.6abc	4.2a	5.1ab	7.3b	14.9b	1463b
Tvu 16408	13.9ab	23.2ab	4.5a	5.6a	7.4b	15.7ab	3240a
Tvu 15143	14.8ab	24.1a	3.9ab	4.9abc	9.9a	18.0a	1823ab
Soil P level	*	**	*	ns	*	**	*
Moisture	ns	ns	ns	ns	ns	ns	ns
Cowpea genotypes	**	**	***	***	*	*	*

Table 2: Pearson correlation among cowpea root characteristics, nodule score and cowpea grain yield

	Angle of basal roots	Stem diameter	Taproot diameter at 5 cm	Taproot diameter at 10 cm	Angle of adventitious roots	Taproot diameter at 15 cm	Basal roots
Angle of base roots	1						
Stem diameter	0.233**	1					
Taproot diameter at 5 cm	0.116	0.761***	1				
Taproot diameter at 10 cm	0.186*	0.624***	0.823***	1			
Angle of adventitious roots	0.500***	0.443***	0.316***	0.255**	1		
Taproot diameter at 15 cm	0.064	0.441***	0.565***	0.714***	0.154*	1	
Deep score	0.353***	0.698***	0.778***	0.831***	0.423***	0.630***	0.381***
Nodule score	0.198*	0.420***	0.297***	0.281**	0.210*	0.421***	0.558***
Diseases	0.126	0.418***	0.371***	0.312***	0.290***	0.220*	0.336***
Grain yield	0.069	0.245**	0.247**	0.247**	0.141	0.179*	0.238**

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